Current assessments

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EBS preliminary: model structures

Model groupings

- Group A consisted of the base model (**Model 0**), in use since the 2011 assessment, and two minor variants (Models 7 and 8)
- Group B consisted of an alternative model introduced in 2014 (**Model 2**), two minor variants (Model 3 and Model 4), and two major variants (**Model 5** and Model 6)
- Data weighting was a major theme in both groups, e.g.
  - Using Equation TA1.8 of Francis (2011)
  - Tuning the mean input sample size to the harmonic mean of the effective sample size
- Specifying constraints on the amount of time variability in various parameters was a major theme in the second group

Model 0: main features

- Age- and time-invariant M, estimated outside the model
- All length-at-age parameters, including σs, estimated internally
- Ageing bias parameters estimated internally
- Gear-and-season-specific catch and selectivity for the fisheries
- Double normal selectivity for the fisheries and survey
- Length-based selectivity for the fisheries
- Age-based selectivity for the survey
- Fishery selectivity estimated for “blocks” of years
- Survey selectivity constant, except *dev*s for *ascending_width*
- Sizecomp data used in all years, including years with agecomps
- Survey Q fixed at 0.77

Model 0: iterative tuning (1 of 2)

- Iterative tuning of time-varying parameters
  - The standard deviations of the two **dev** vectors in Model 0 (the log of age 0 recruitment and the survey *ascending_width* parameter, both additive) were estimated iteratively during the 2009 assessment by setting σ=stdev(**dev**)
  - Although this method is more justifiable than simply guessing at the value of σ, it is known to be biased low, and can easily return a value of zero even when the true value is substantially greater than zero
  - Per request of the BSAI Plan Team, the values of these σ terms (0.57 and 0.07, respectively) have been held constant in Model 0 and its predecessors ever since the 2009 assessment

Model 0: iterative tuning (2 of 2)

- Iterative tuning of survey catchability
  - Survey catchability (Q) was estimated iteratively during the 2009 assessment by tuning Q so that the average of the product of Q and survey selectivity across the 60-81 cm size range matched the point estimate of 0.47 given by Nichol et al. (2007)
  - Per request of the BSAI Plan Team, this value of Q (0.77) has been held constant in Model 0 and its predecessors ever since the 2009 assessment

Main differences between Models 2 and 0

- Each year consisted of a single season instead of five
- A single fishery was defined instead of nine season-and-gear-specific fisheries
- 10 age groups were estimated in the initial vector (vs. 3)
- The natural mortality rate was estimated internally
- The base value of Q was estimated internally
- Q was allowed to vary annually
- Selectivity for both fishery and survey were allowed to vary annually
- Selectivity for both the fishery and survey was modeled using a random walk with respect to age instead of the double normal
- Tuning procedures (see next slides)

Model 2: iterative tuning (1 of 2)

- Prior distributions for selectivity parameters
  - Basic idea is to specify a prior that would cause selectivity to default to logistic in the absence of information
  - Vaguely informative (CV no smaller than 50% at any age)
- Iterative tuning of time-varying selectivity parameters
  - Compute an "unconstrained" estimate of the std. dev. of the set of year-specific *dev*s associated with each age
  - Compute an "iterated" estimate of the std. dev. of the set of year-specific *dev*s associated with each age
  - Apply equation of Thompson and Lauth (2012)
  - This procedure resulted in most *dev* vectors being "tuned out"
- A similar procedure was used for tuning σ_R

Model 2: iterative tuning (2 of 2)

- Iterative tuning of time-varying catchability
  - Although conceptually similar to a dev vector, SS treats each annual deviation in $\ln(Q)$ as a true parameter, with its own prior
  - Because SS works in terms of $\ln(Q)$ rather than Q, normal prior distributions were assumed for all annual deviations
  - A single σ was assumed for all such prior distributions
  - Unlike the size or age composition data sets, the time series of survey abundance data includes not only a series of expected values, but a corresponding series of standard errors as well
  - The procedure involved iteratively adjusting σ until the RMSSR for survey abundance equaled unity

Main differences between Models 5 and 2

- For composition data, arithmetic mean input N was set equal to min(300, *harmonic* mean effective N)
  - *Arithmetic* mean effective N was used in Model 2
- 20 age groups were estimated in the initial vector (vs. 10)
- Selectivity at ages 9+ was constrained to equal selectivity at age 8 for both the fishery and the survey (vs. free at all ages)
- SS runs were accepted even if the gradient was large, so long as the covariance matrix of the parameters appeared reasonable
  - Model 6 was the same as Model 5, except that SS runs with large gradients were not accepted
- Tuning procedures (see next slides)

Model 5: iterative tuning (1 of 2)

- A major difference from Model 2:
  - In Model 2, iterative tunings were conducted *sequentially* (i.e., 1 group of parameters at a time)
  - In Model 5, all iterative tunings were conducted *simultaneously*
- Iterative tuning of prior distributions for selectivity:
  - Except for the difference noted above, iterative tuning of prior distributions for selectivity parameters in Model 5 proceeded as in Model 2
- Iterative tuning of catchability:
  - Same procedure as Model 2
  - However, unlike Model 2, this procedure ended up "tuning out" catchability *dev*s in Model 5 (not so in Model 6, though)

Model 5: iterative tuning (2 of 2)

- Iterative tuning of selectivity and recruitment σs
  - The approach used in Model 2 (Thompson and Lauth 2012) was not retained in Model 5
  - For a *univariate* model, *if* the method used in Model 2 returns a non-zero estimate of σ, there is reason to believe that this estimate will be unbiased
  - However, performance in a *multivariate* model is unclear
  - Moreover, the method carries a fairly high probability of returning a "false negative;" that is, returning a zero estimate for σ when the true value is non-zero
  - To reduce this bias toward under-parameterization, the method of Thompson (2015) was used (see SAFE, MS)

EBS preliminary: results

Big picture (1 of 4)

- Female spawning biomass (t), relative to $B_{100\%}$:

	Model 0		Model 2		Model 3		Model 4	
Quantity	Value	SD	Value	SD	Value	SD	Value	SD
FSB 2015	402,931	28,093	230,635	37,456	174,652	22,218	228,697	37,210
Bratio 2015	0.520	0.030	0.308	0.052	0.228	0.030	0.304	0.052

	Model 5		Model 6		Model 7		Model 8	
Quantity	Value	SD	Value	SD	Value	SD	Value	SD
FSB 2015	350,833	67,941	374,668	93,431	406,728	28,258	403,032	28,123
Bratio 2015	0.553	0.095	0.443	0.087	0.522	0.030	0.521	0.030

Big picture (2 of 4)

- Natural mortality rate M was fixed at a value of 0.34 in Models 0, 7, and 8; but estimates in the other models ranged from 0.31 (Model 3) to 0.48 (Model 5)
- Catchability Q was fixed at a value of 0.77 in Models 0, 7, and 8; but estimates in the other models ranged from 0.87 (Model 6) to 1.65 (Model 3)

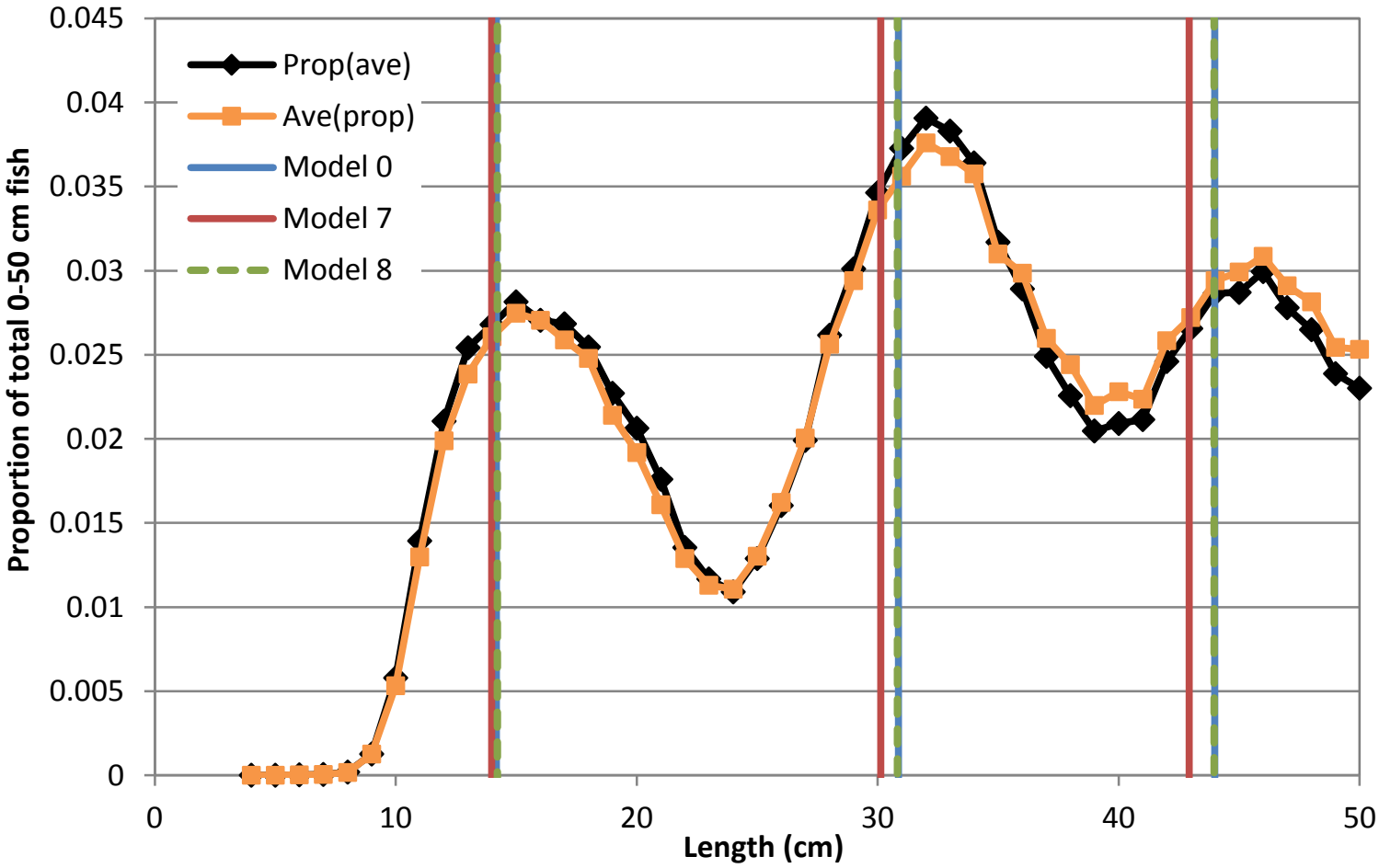
Big picture (3 of 4)

- Fit to survey index data:
  - Models 2, 4, and 6 fit the survey abundance data well
    - Root mean squared errors close to the log-scale standard error in the data
    - Standard deviation of normalized residuals close to unity
  - Model 5 overfit the survey abundance data
    - Francis (2011) says this is not necessarily bad
  - Models 0, 7, and 8 underfit the survey abundance data

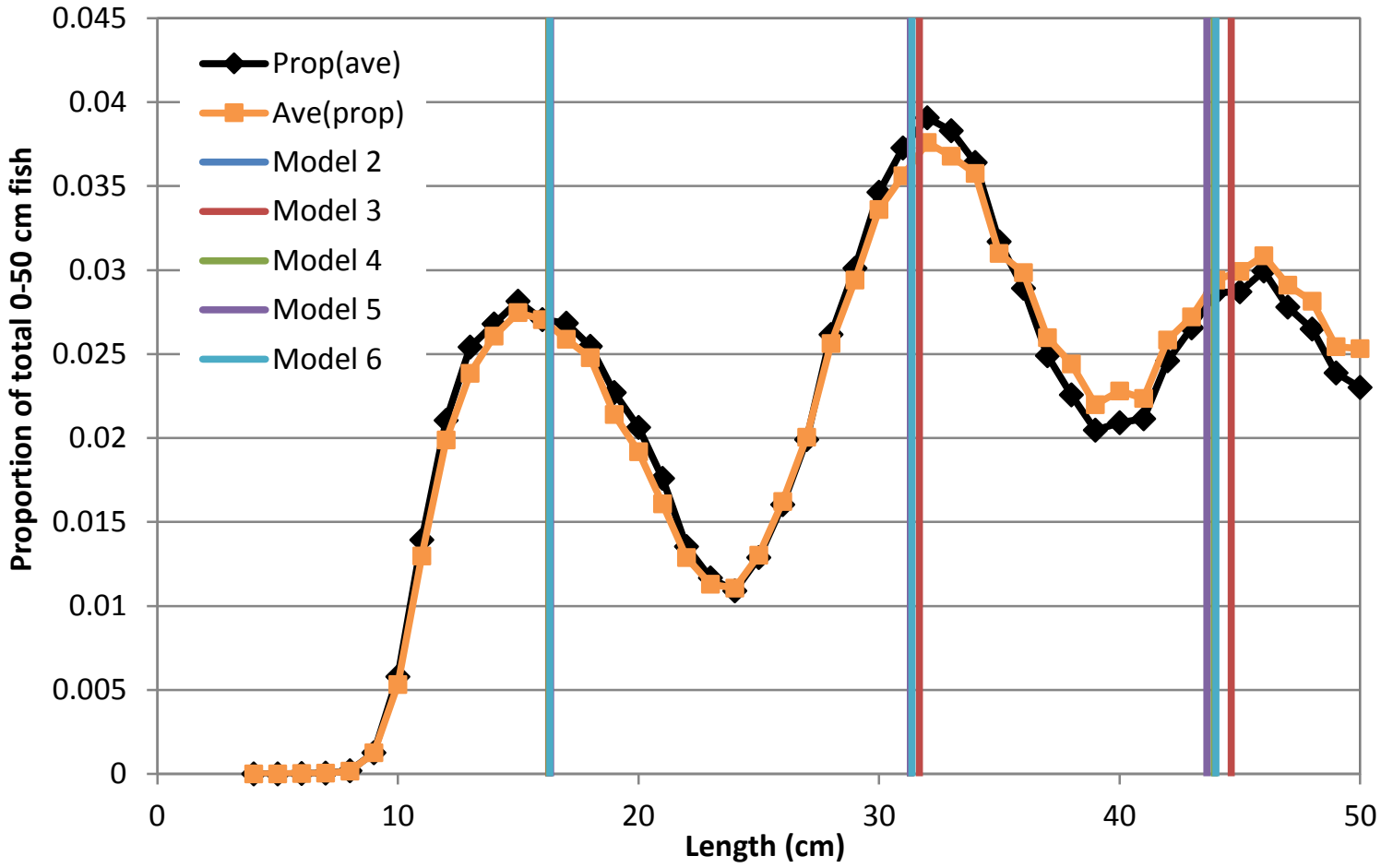
Big picture (4 of 4)

- Fit to size composition data:
  - All models generally provided good-to-excellent fits to the size composition data
- Fit to age composition data:
  - Models 0 and 8 do not give particularly good fits
  - Models 2-7 all produce an *arithmetic* mean effective N larger than the arithmetic mean input N
  - Only Models 3, 5, and 6 produce a *harmonic* mean effective N as large as the arithmetic mean input N
    - However, these models accomplish this, at least in part, by decreasing the input sample sizes

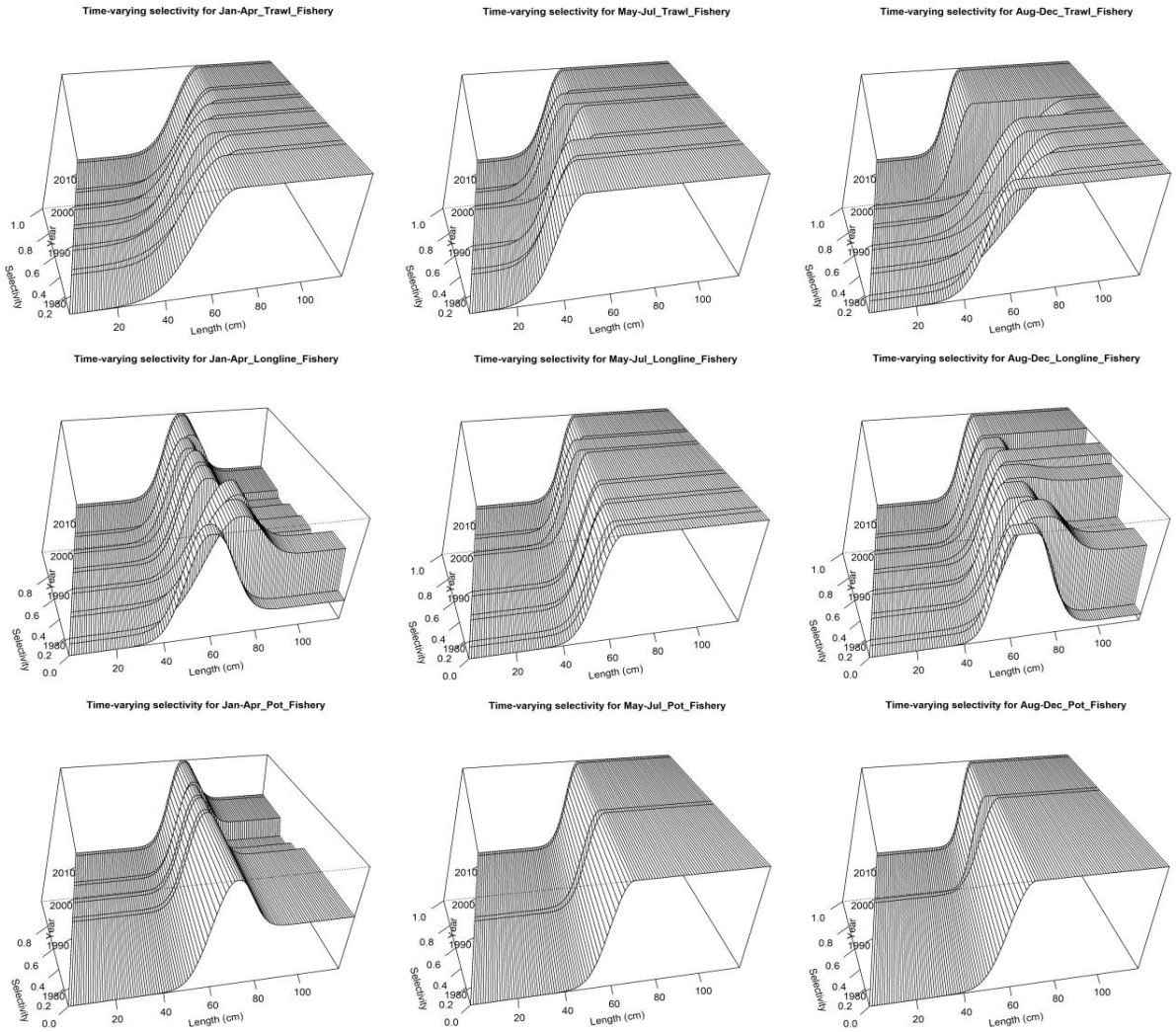
Size at age vs. sizecomp modes: Models 0,7,8



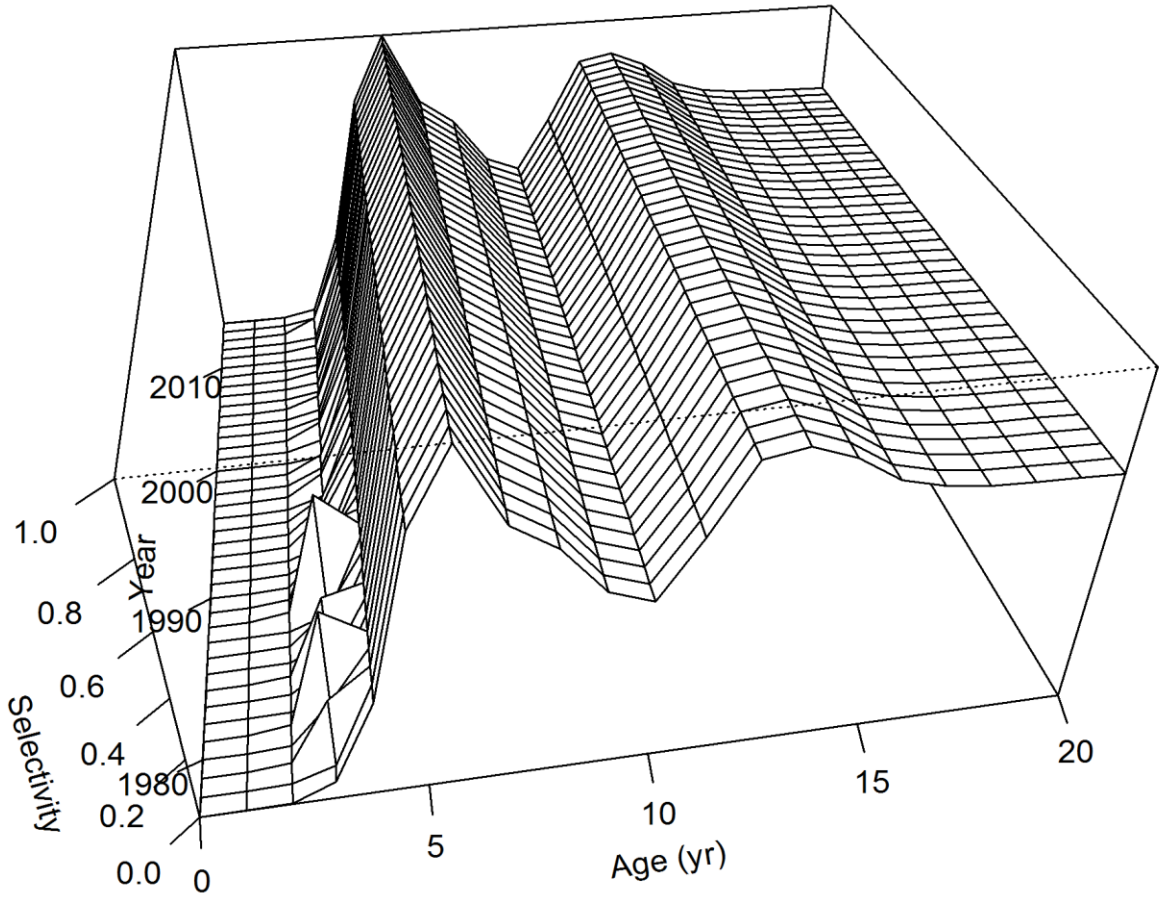
Size at age vs. sizecomp modes: Models 2-6



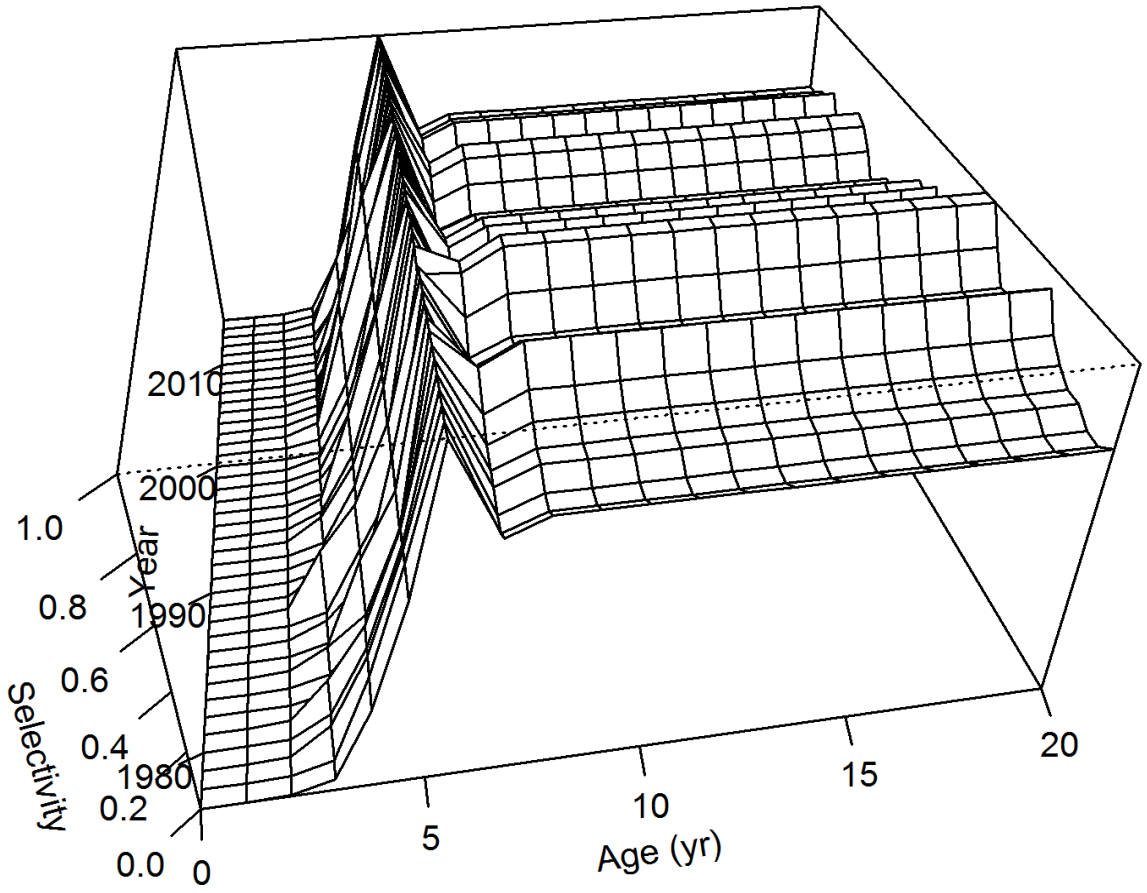
Fishery selectivity: Model 0



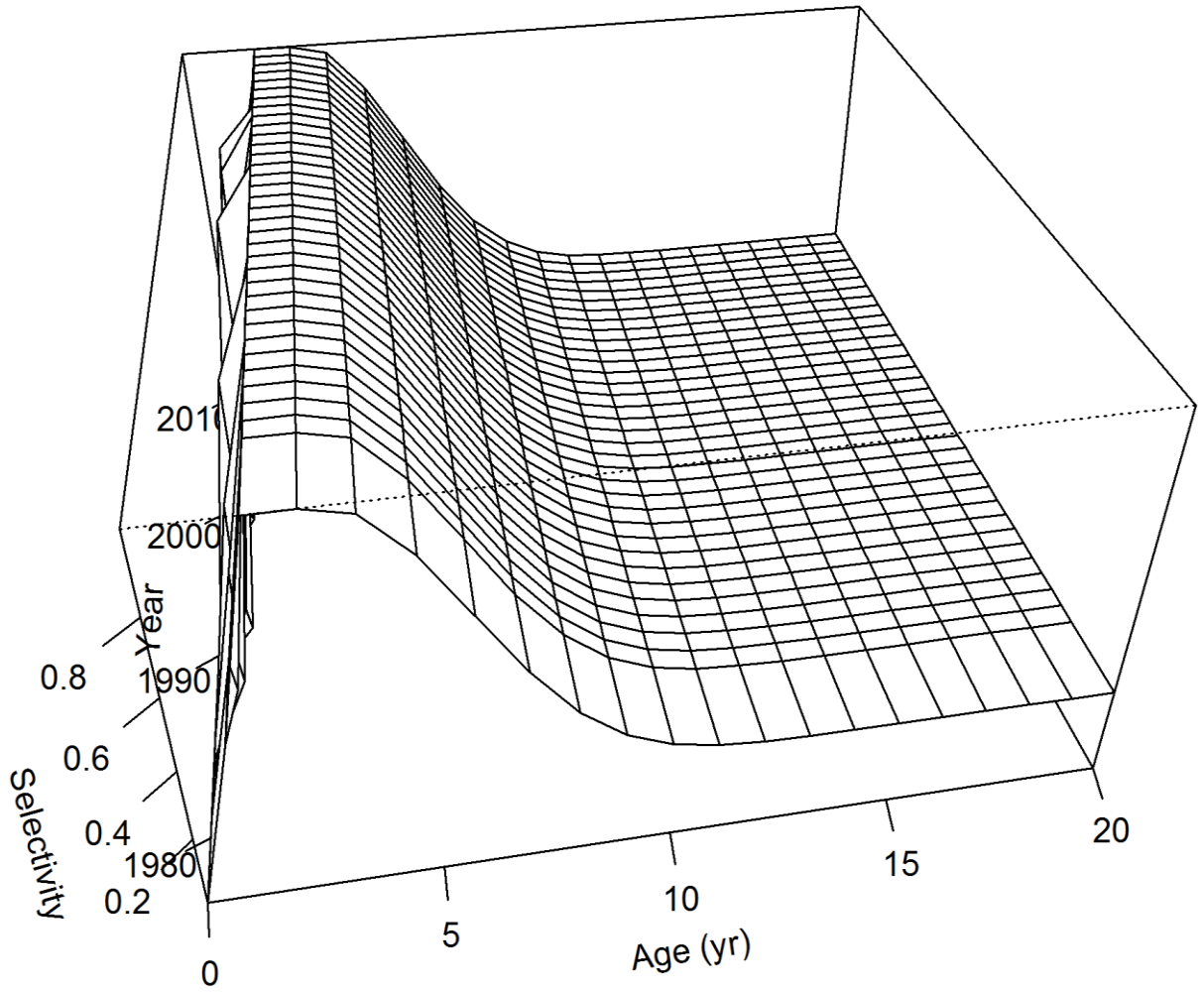
Fishery selectivity: Model 2



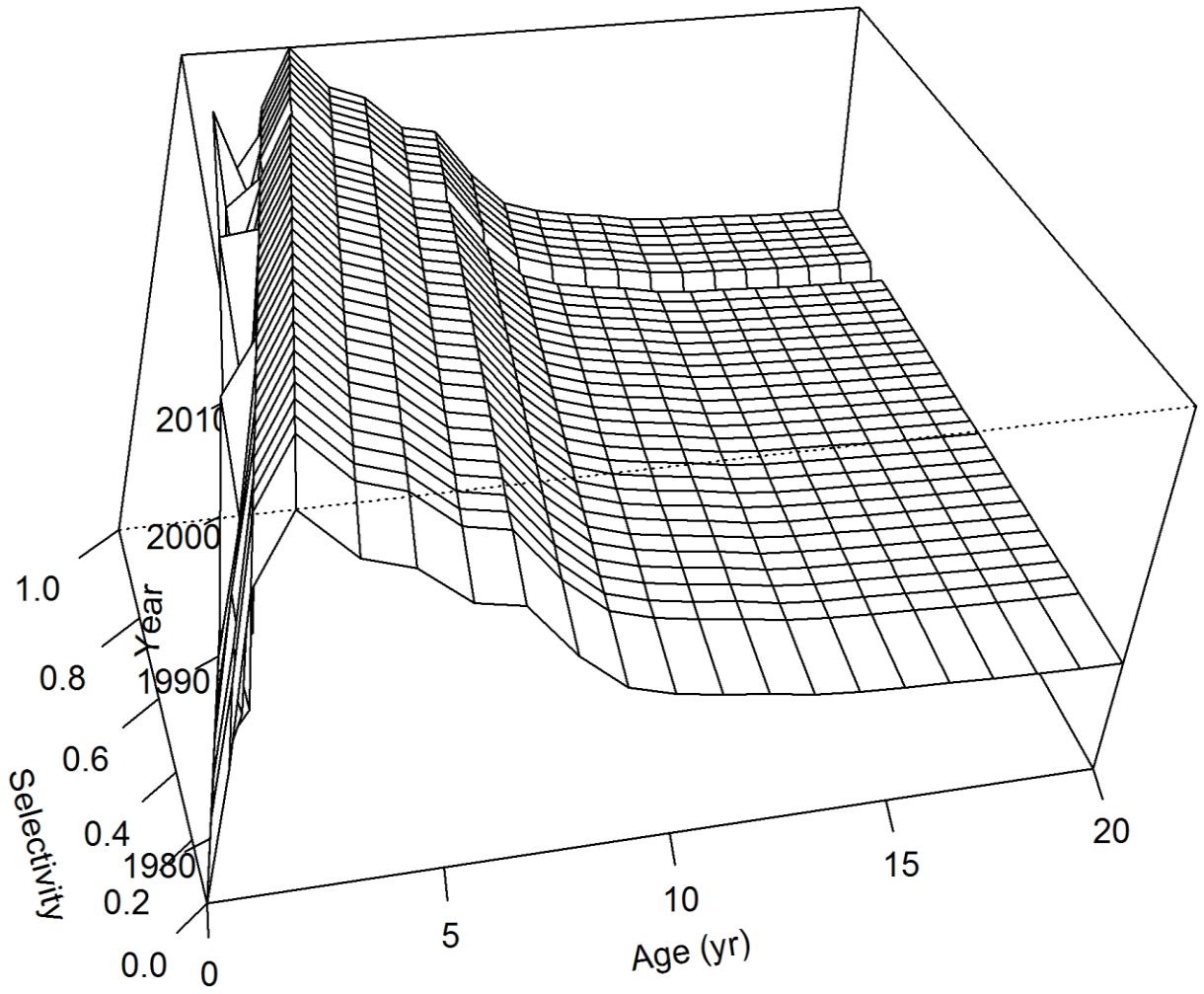
Fishery selectivity: Model 5



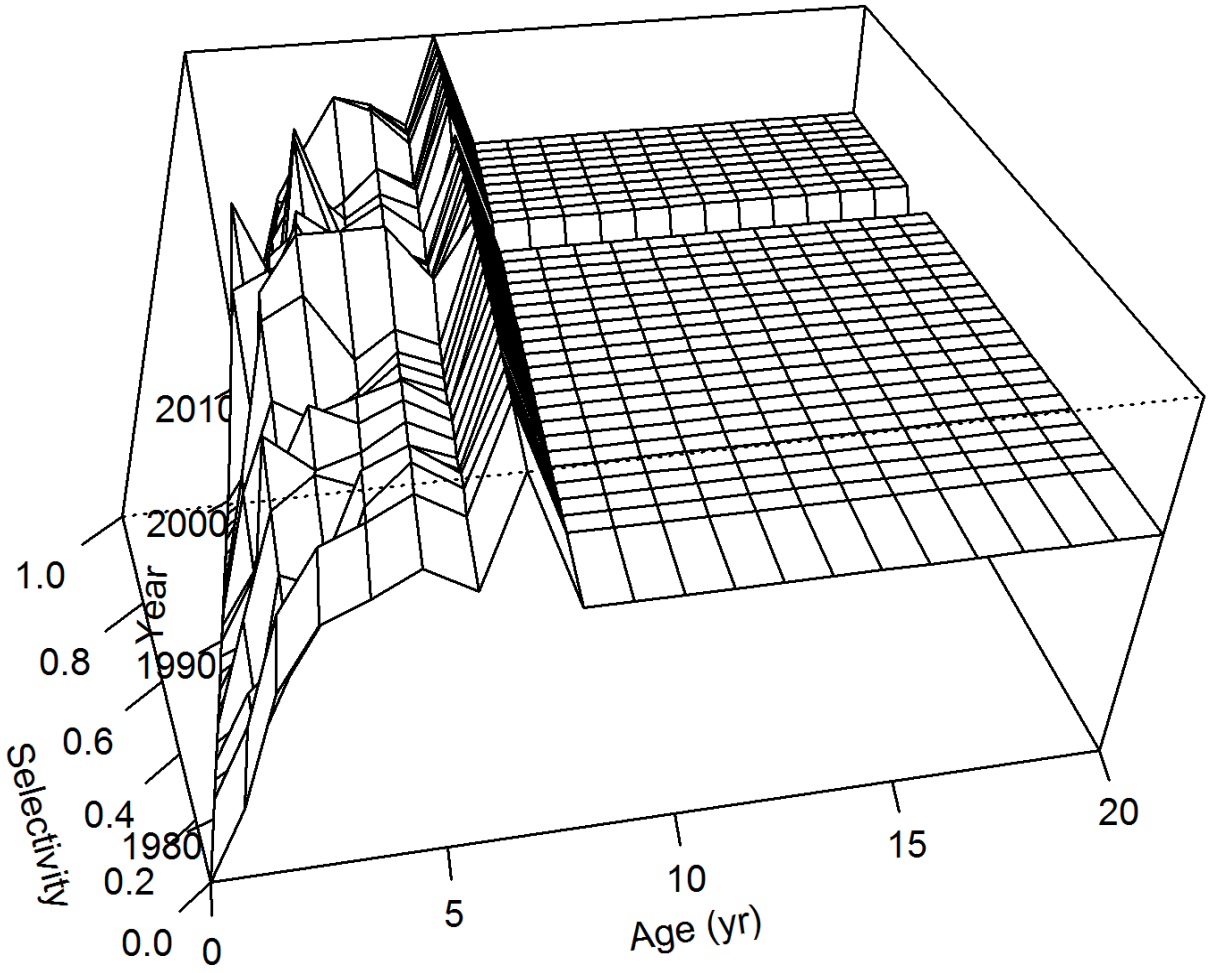
Survey selectivity: Model 0



Survey selectivity: Model 2

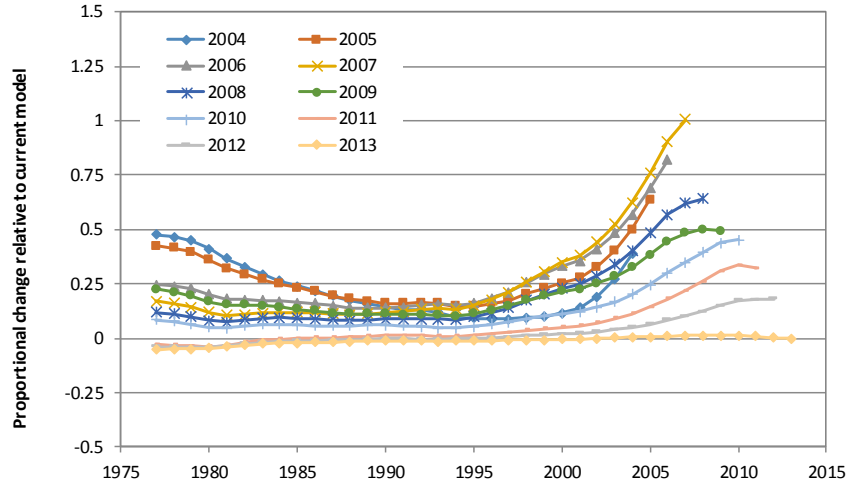


Survey selectivity: Model 5

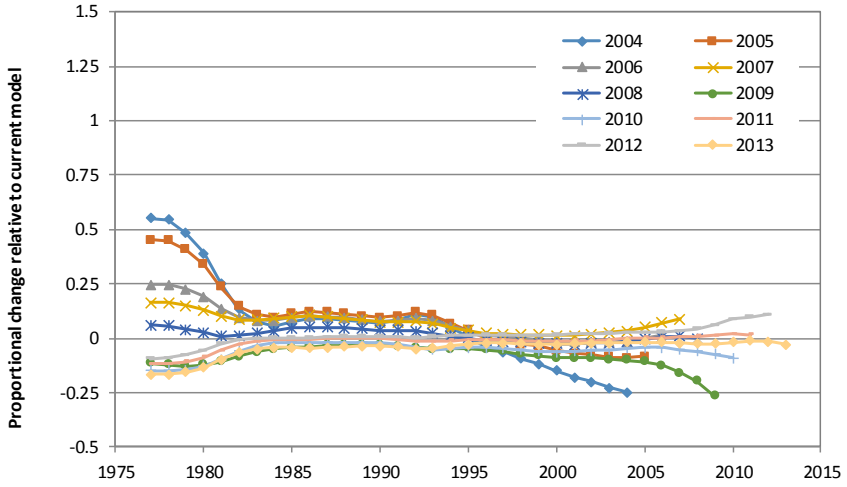


Restrospectives (relative): Models 0-4

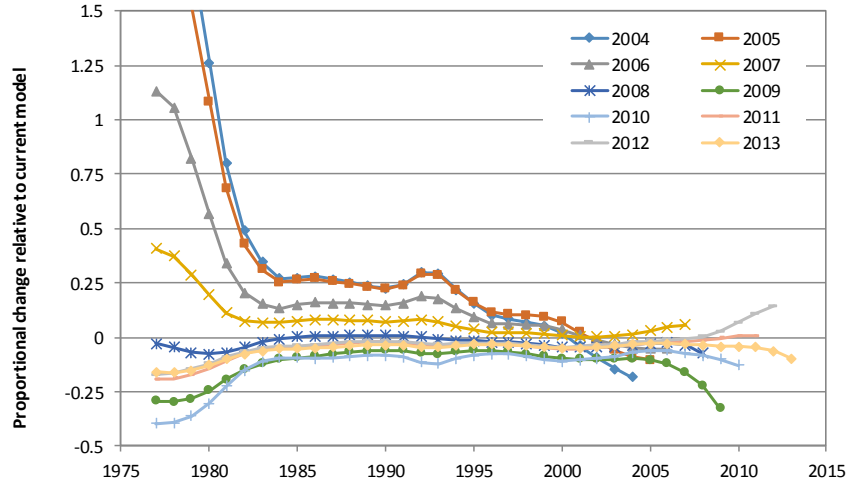
Model 0, rho = 0.494



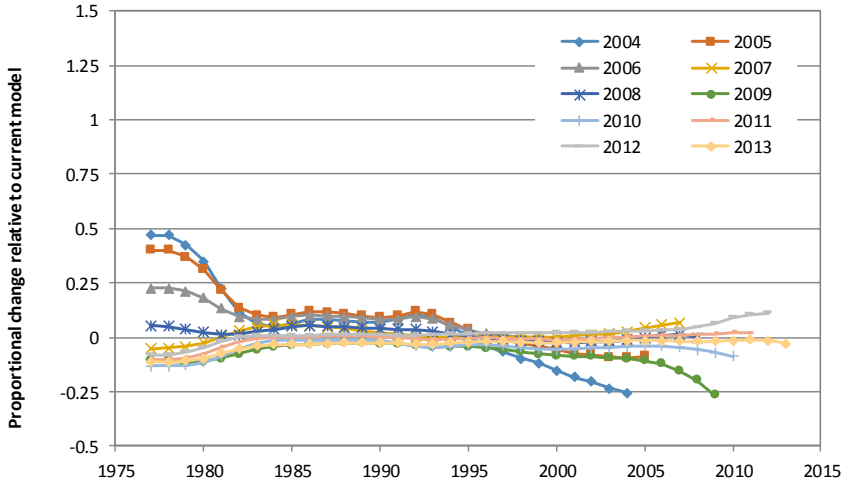
Model 2, rho = -0.049



Model 3, rho = -0.076

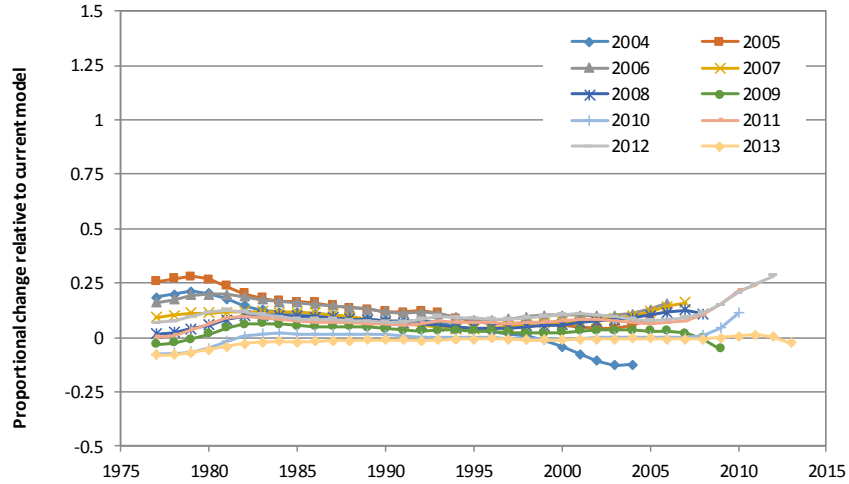


Model 4, rho = -0.051

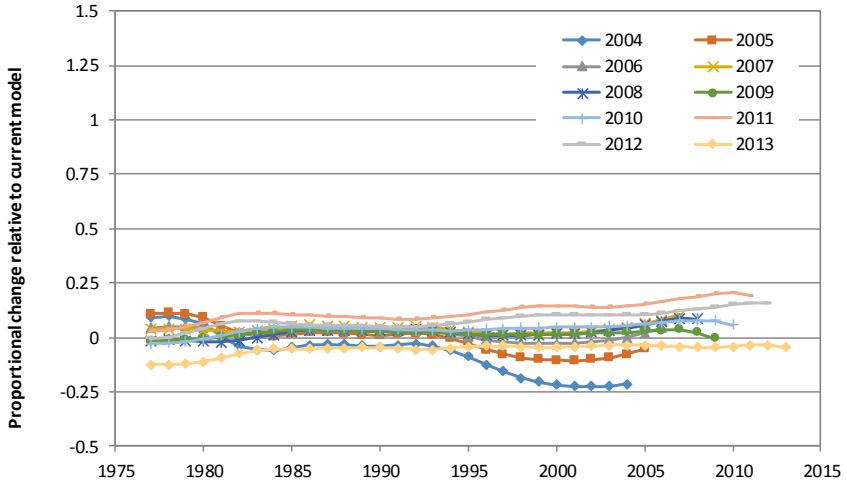


Restrospectives (relative): Models 5-8

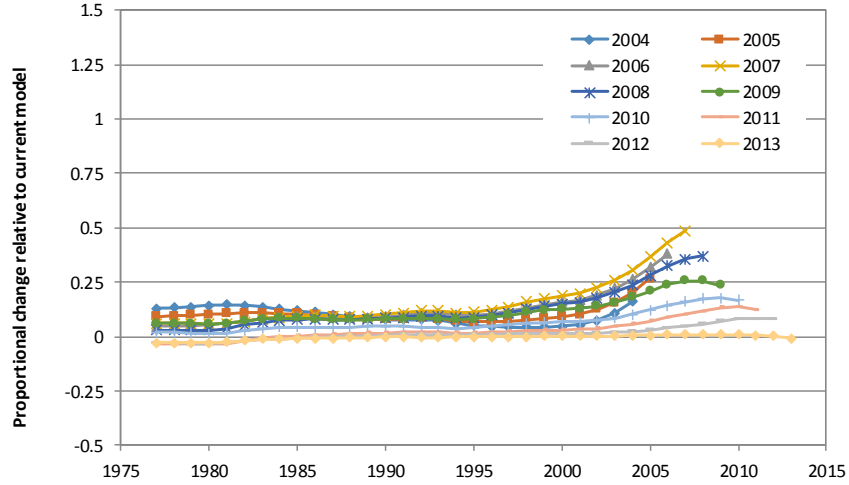
Model 5, rho = 0.095



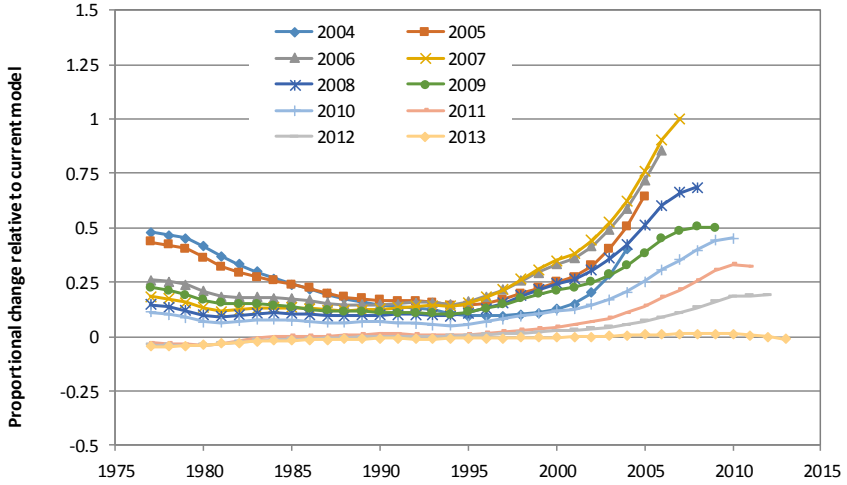
Model 6, rho = 0.032



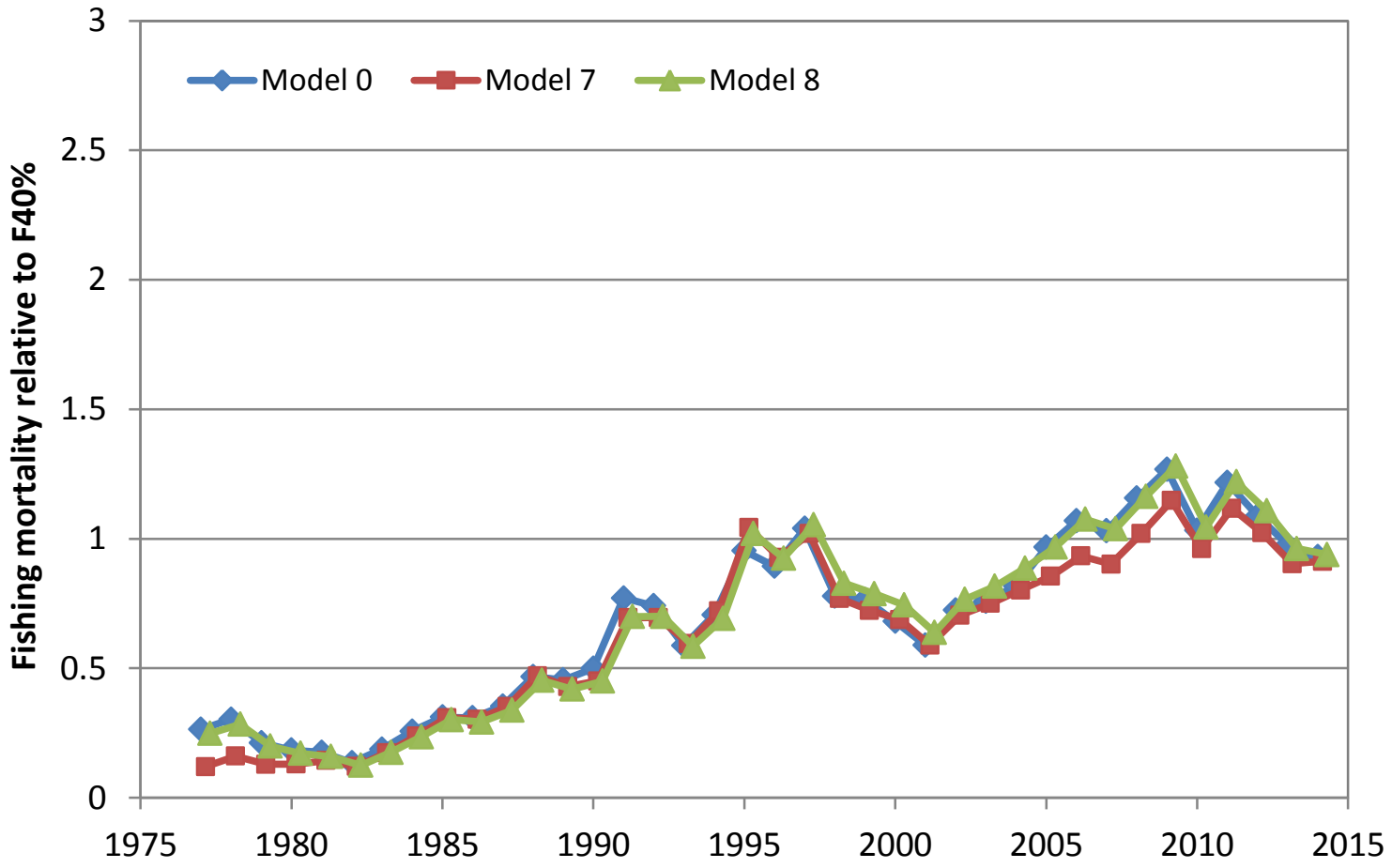
Model 7, rho = 0.226



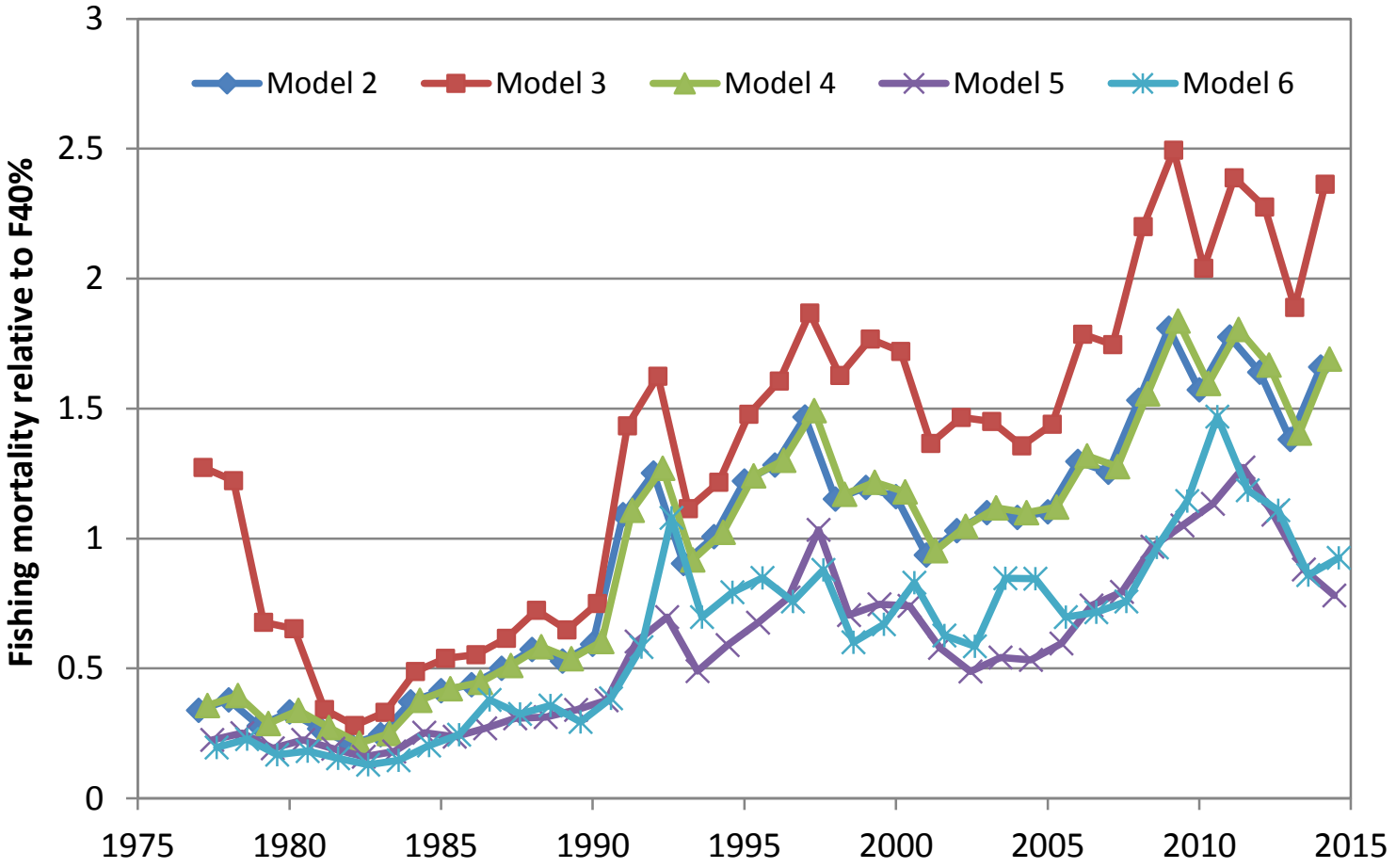
Model 8, rho = 0.505



Ratio of F to F40%: Models 0, 7, 8



Ratio of F to F40%: Models 2-6

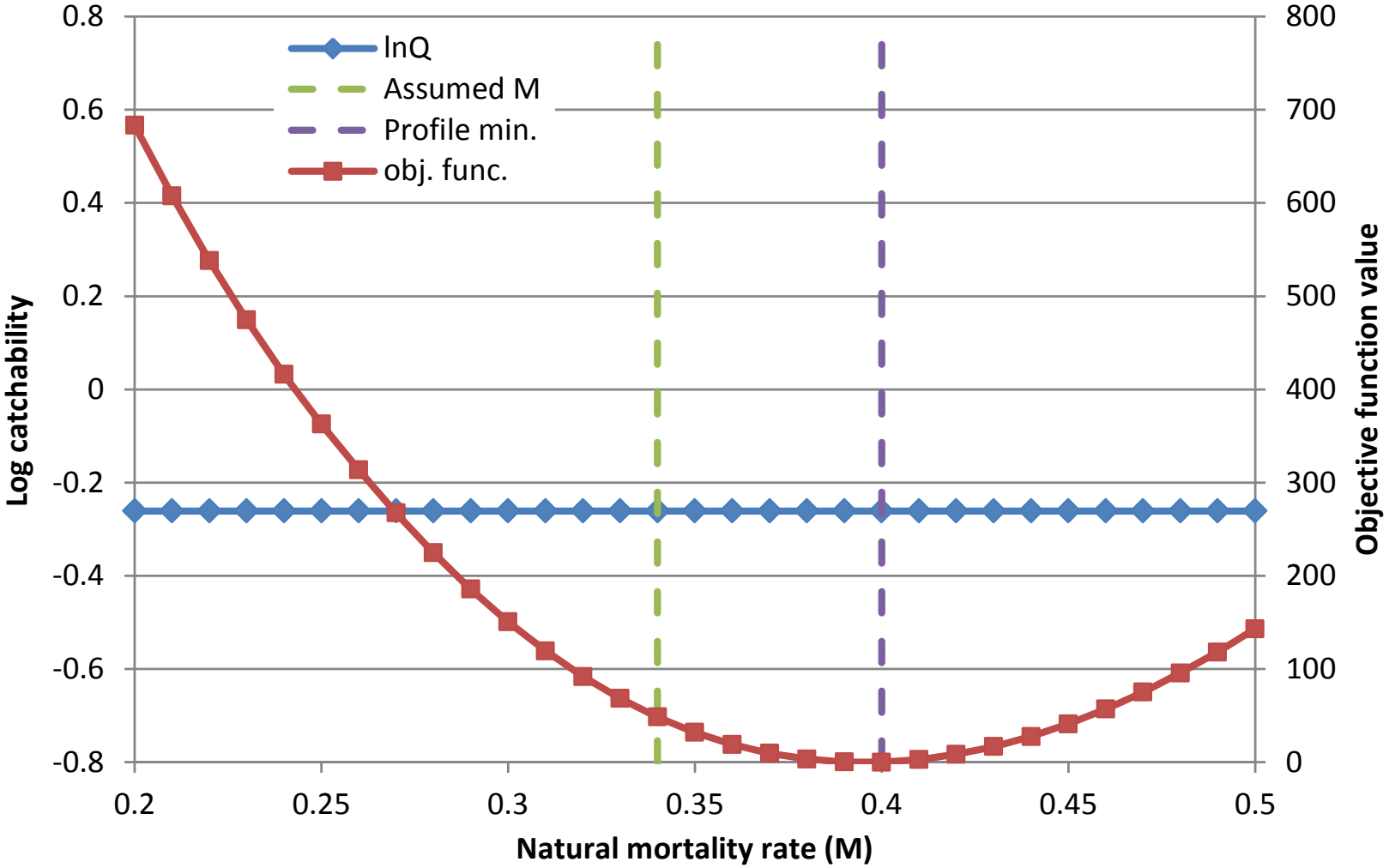


EBS final assessment

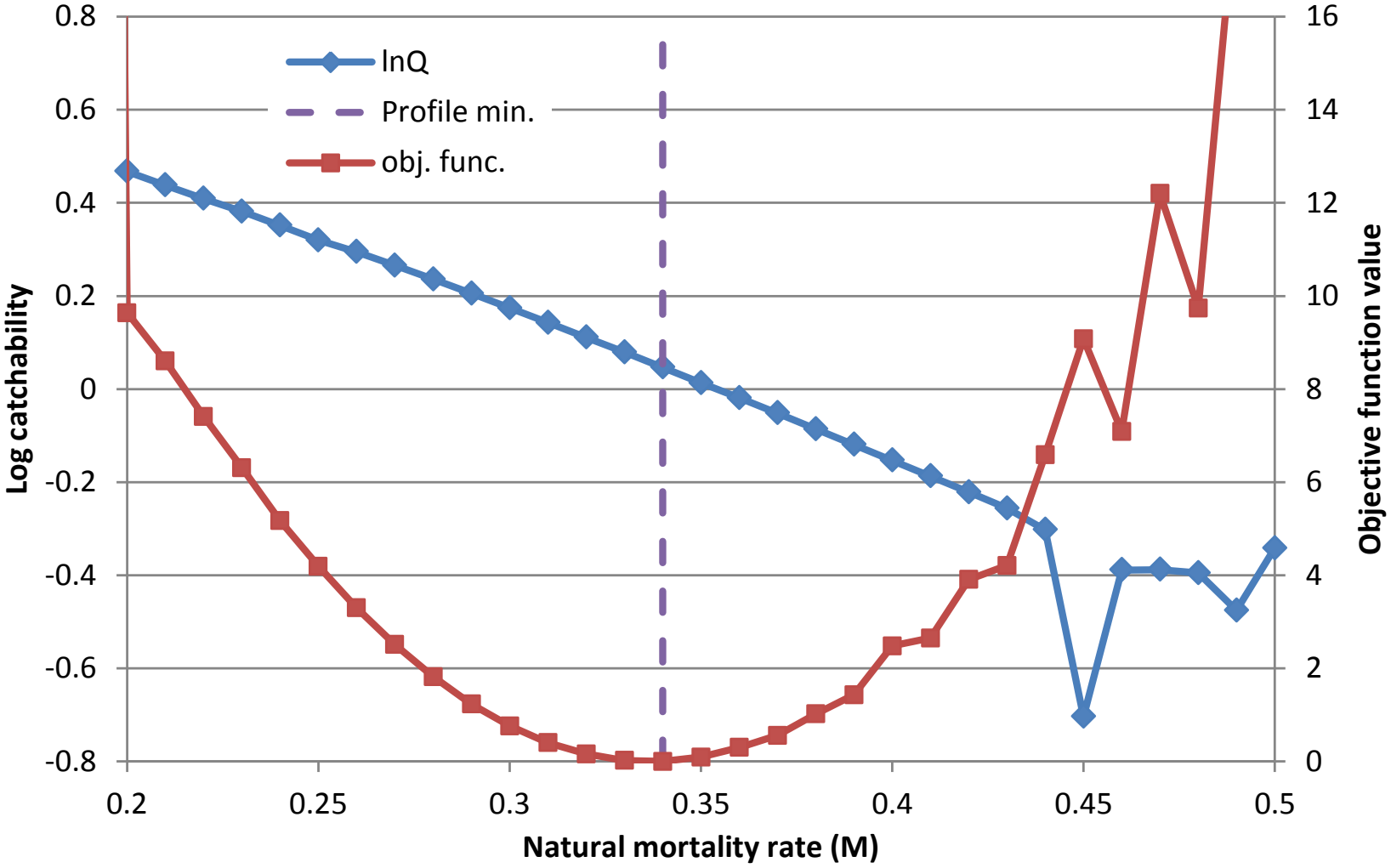
Overview

- Models 0 and 2, renamed Models 11.5 and 14.2, were carried forward to the final assessment, with no changes except for updated data
- Results qualitatively very similar to preliminary assessment
- The next few slides show some material that was not featured in the preliminary assessment

Likelihood profile w.r.t. M (Model 11.5)



Likelihood profile w.r.t. M (Model 14.2)

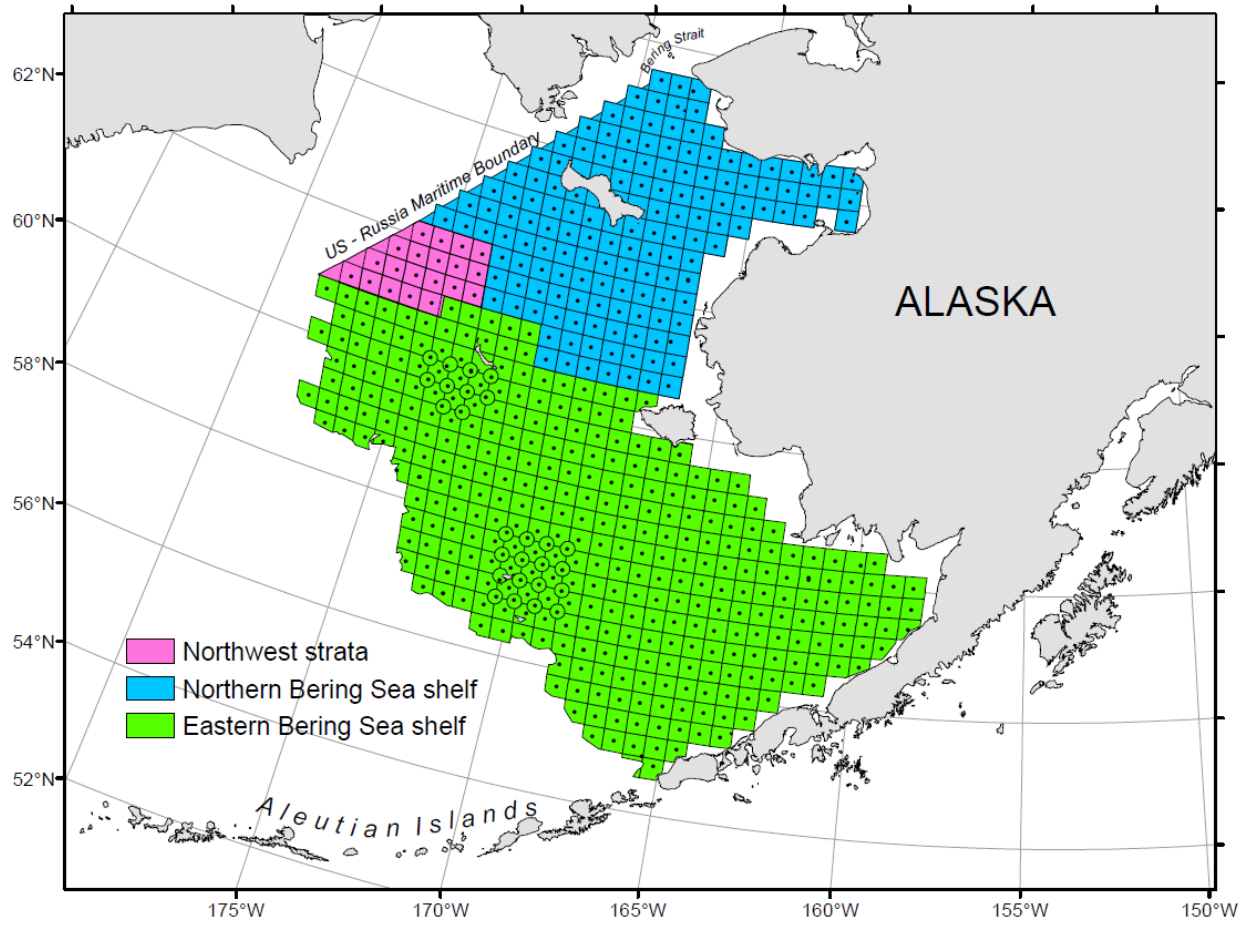


SSC "missing biomass" hypothesis (1 of 4)

- In the context of the model structures, the data used in those models suggest strongly that survey selectivity has a steeply declining right-hand limb, and Model 11.5 assumes that Q is substantially less than 1.0 (Model 14.2 estimates Q=1.06)
- As a result of their estimated survey selectivity schedules (and, in the case of Model 11.5, the assumed value of Q), both models provide estimates of total biomass that are, on average, much larger than the average survey biomass
- According to the models, the EBS survey misses an average of 42% (Model 11.5) or 23% (Model 14.2) of the total biomass
- The SSC has suggested that the descending limb of survey selectivity might be explained, at least in part, by fish moving out of the EBS survey area during the summer and into the NBS

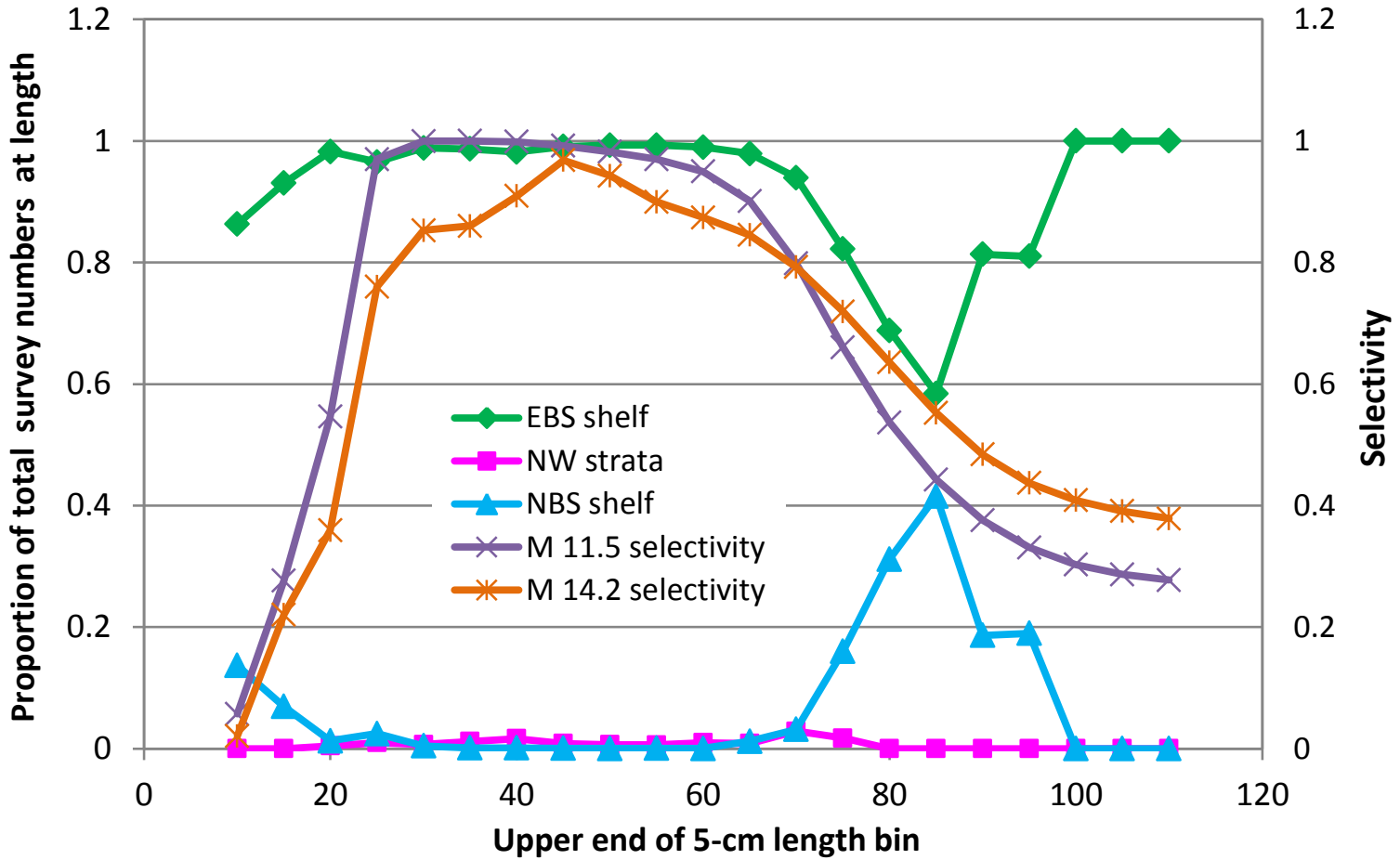
SSC “missing biomass” hypothesis (2 of 4)

- Bottom trawl survey areas:



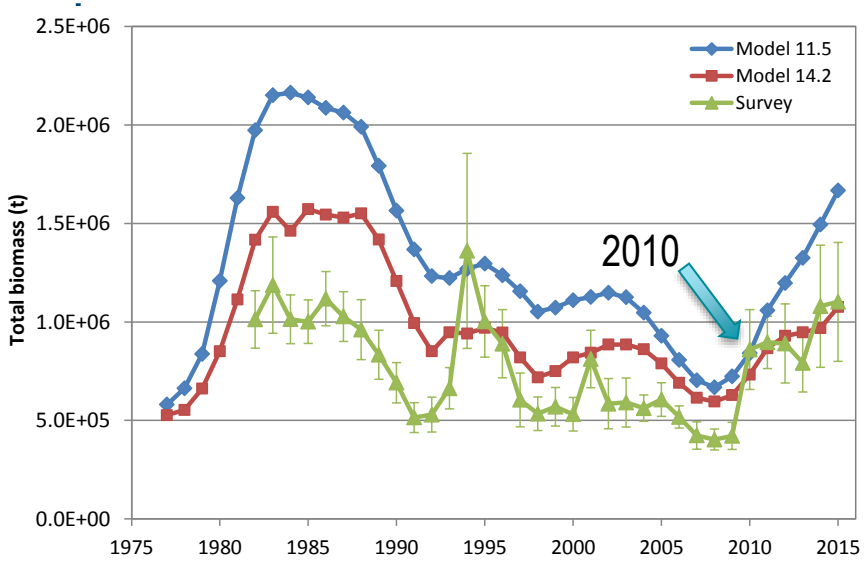
SSC "missing biomass" hypothesis (3 of 4)

- Sizecomps from the 2010 EBS and NBS surveys, selectivities:



SSC "missing biomass" hypothesis (4 of 4)

- Even if migration into the NBS were to explain much of the descending selectivity limb, it is not clear that is would explain most of the discrepancy between survey biomass and model biomass
  - Average discrepancy: 42% or 23%, depending on model
  - In 2010, NBS accounted for only 3% of EBS+NBS biomass
  - However, 2010 was unusual in the EBS survey/model time



- If distribution of NBS and EBS biomass in 2010 is typical, then NBS *does not* account for the average discrepancy
- However, if 2010 is an outlier, and fish simply did not undertake their typical (presumed) migration during that one year, then NBS *might* account for the discrepancy

AI preliminary: models

Starting point: differences from EBS model

- Each year consisted of 1 season instead of 5
- 1 fishery was defined instead of 9 season×gear fisheries
- The standard deviation of log-scale age 0 recruitment (σ_R) was estimated internally instead of being estimated outside the model
- Log-scale Q was estimated internally, using a normal prior distribution with μ=0.00 and σ=0.11
- 10 age groups were estimated in the initial vector (vs. 3)
- Selectivity for both the fishery and survey was modeled using a random walk with respect to age instead of the usual double normal
- Potentially, each selectivity parameter was allowed to be time-varying with annual additive *devs*
  - Tuning procedure similar to EBS preliminary Models 2-4

List of models

- Model 0 was the standard Tier 5 “random effects” model
- Models 2-5 were age-structured SS models, based on the starting point model, and spanning a 2×2 factorial design:
  - New features or methods based on experience with this year’s preliminary assessment of the EBS Pacific cod stock (similar to Model 6 in the EBS preliminary assessment)
    - Did include or did not
  - Historic fishery time series data from 1977-1990
    - Did include or did not

Factorial design: Models 2-5

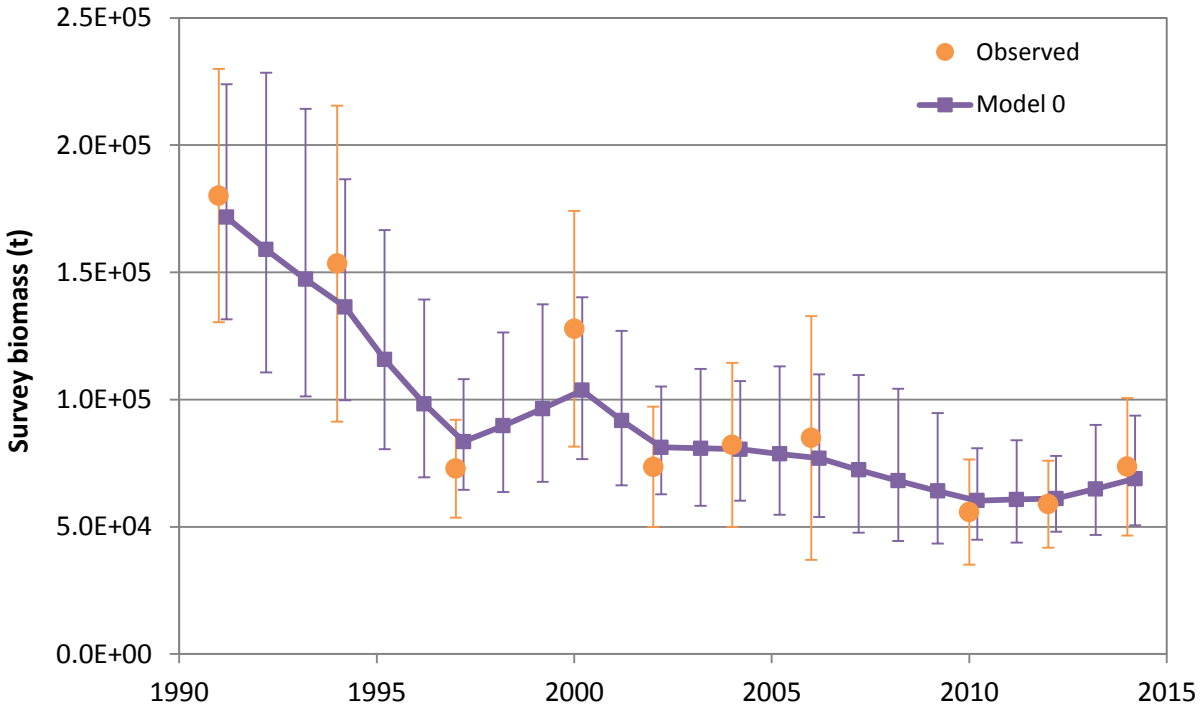
- Model 2: did incorporate the new features/methods; did not use the historic fishery data
- Model 3: did not incorporate the new features/methods; did use the historic fishery data
- Model 4: did not incorporate the new features/methods; did not use the historic fishery data
  - Same as “Model 2” from 2014 AI assessment
- Model 5: did incorporate the new features/ methods; did use the historic fishery data

New features/methods: Models 2&5 versus 3&4

- σ_R was estimated iteratively instead of being estimated internally
- Richards growth was assumed instead of von Bertalanffy growth
- 20 age groups were estimated in the initial vector (vs. 10)
- Catchability Q was allowed to vary annually if RMSSR>1
  - This resulted in time-varying Q for Model 5 but not for Model 2
- Selectivity constant at ages 7+ (fishery) and 8+ (survey)
- For composition data, *arithmetic* mean input N was set equal to min(300, *harmonic* mean effective N)
  - As in EBS preliminary Models 5-6
- Difference in procedure for tuning σ for **dev** vectors similar to that between EBS preliminary Models 5-6 and 2-4

AI preliminary: results

Model 0 fit to survey biomass time series



Statistic	Value
Correlation (observed:expected)	0.98
Root mean squared error	0.11
Mean normalized residual	0.06
Standard deviation of normalized residuals	0.63

Big picture: age-structured models (1 of 2)

- Female spawning biomass (t), relative to $B_{100\%}$:

	Model 2		Model 3		Model 4		Model 5	
Quantity	Value	SD	Value	SD	Value	SD	Value	SD
FSB 2015	69,931	10,219	95,654	25,010	58,459	8,764	61,293	9,838
Bratio 2015	0.514	0.044	0.577	0.081	0.452	0.046	0.397	0.046

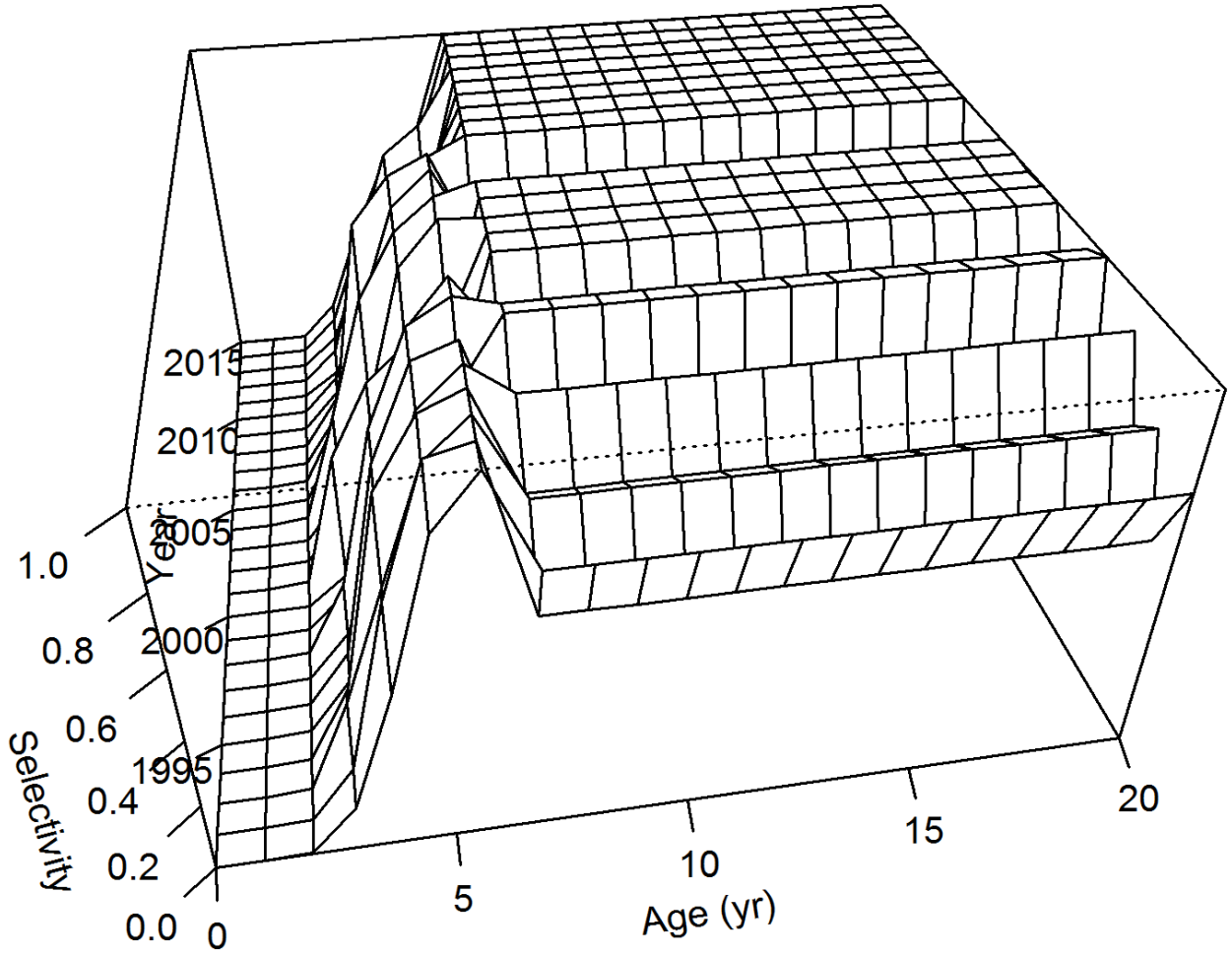
- Average value of the ratio between total biomass and survey biomass:

	Model 2	Model 3	Model 4	Model 5
Ratio:	3.40	4.68	3.31	3.72

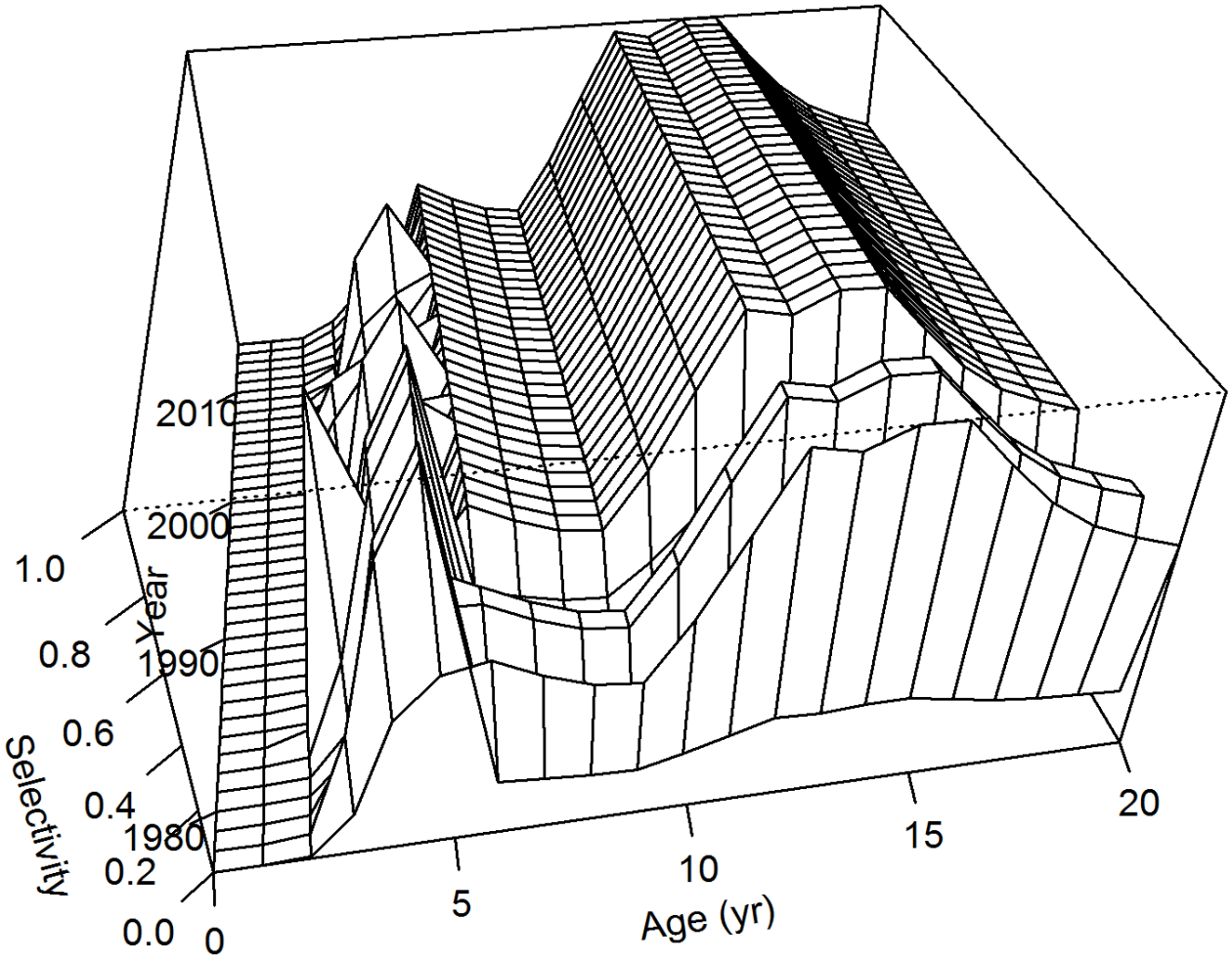
Big picture: age-structured models (2 of 2)

- For survey abundance, all four age-structured models resulted in RMSEs fairly close to the mean standard error in the data, and gave standard deviations for the normalized residuals close to 1
  - All but Model 3 had mean normalized residuals far from 0
- Models 2-5 all provided good fits to the size composition data
- Models 2 and 5 fit the agecomp data well, but Model 3 did not, and Model 4's acceptability depends on which measure is used
  - Note that Models 2 and 5 tune the arithmetic mean input sample size to match the harmonic mean effective sample size

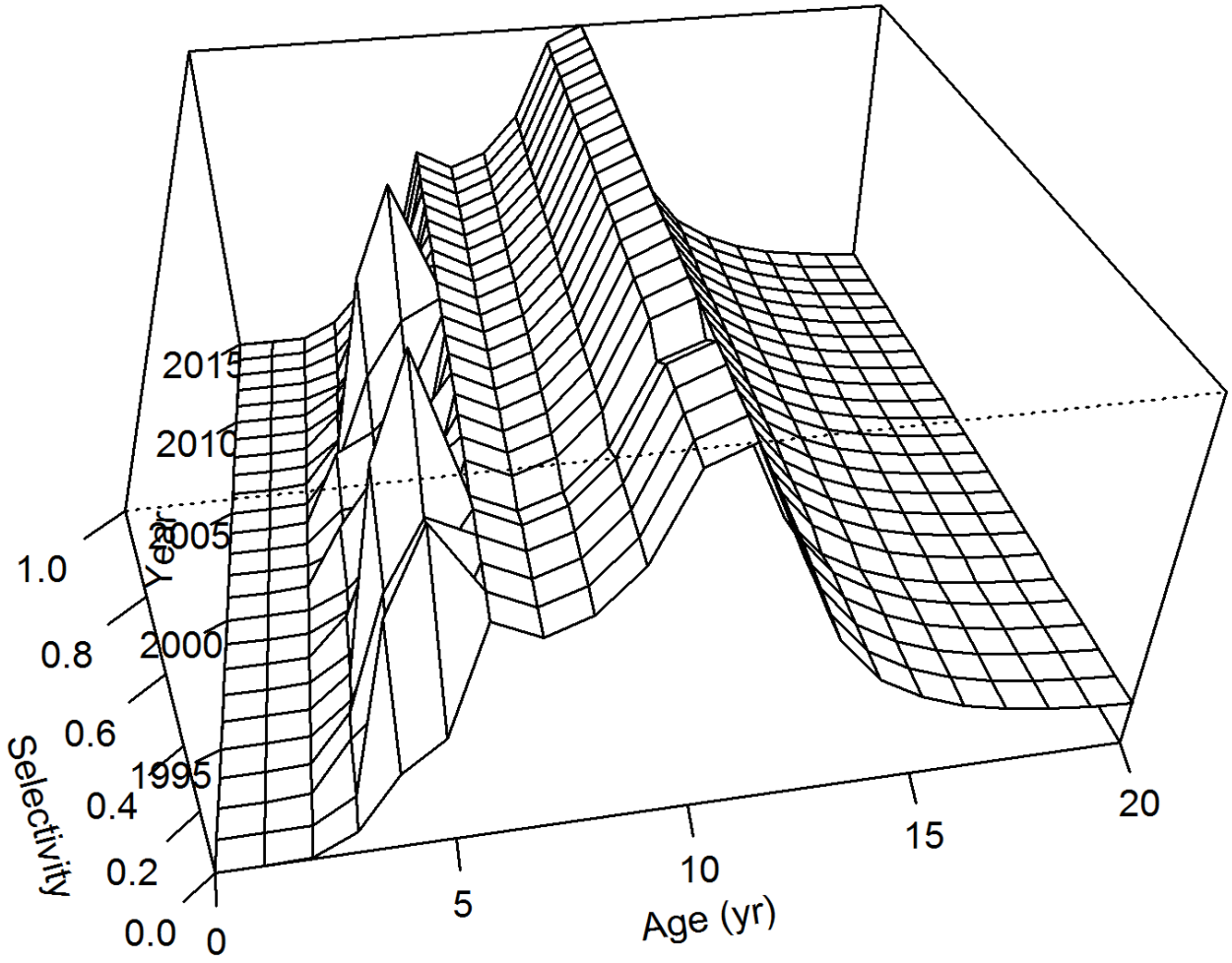
Fishery selectivity (Model 2)



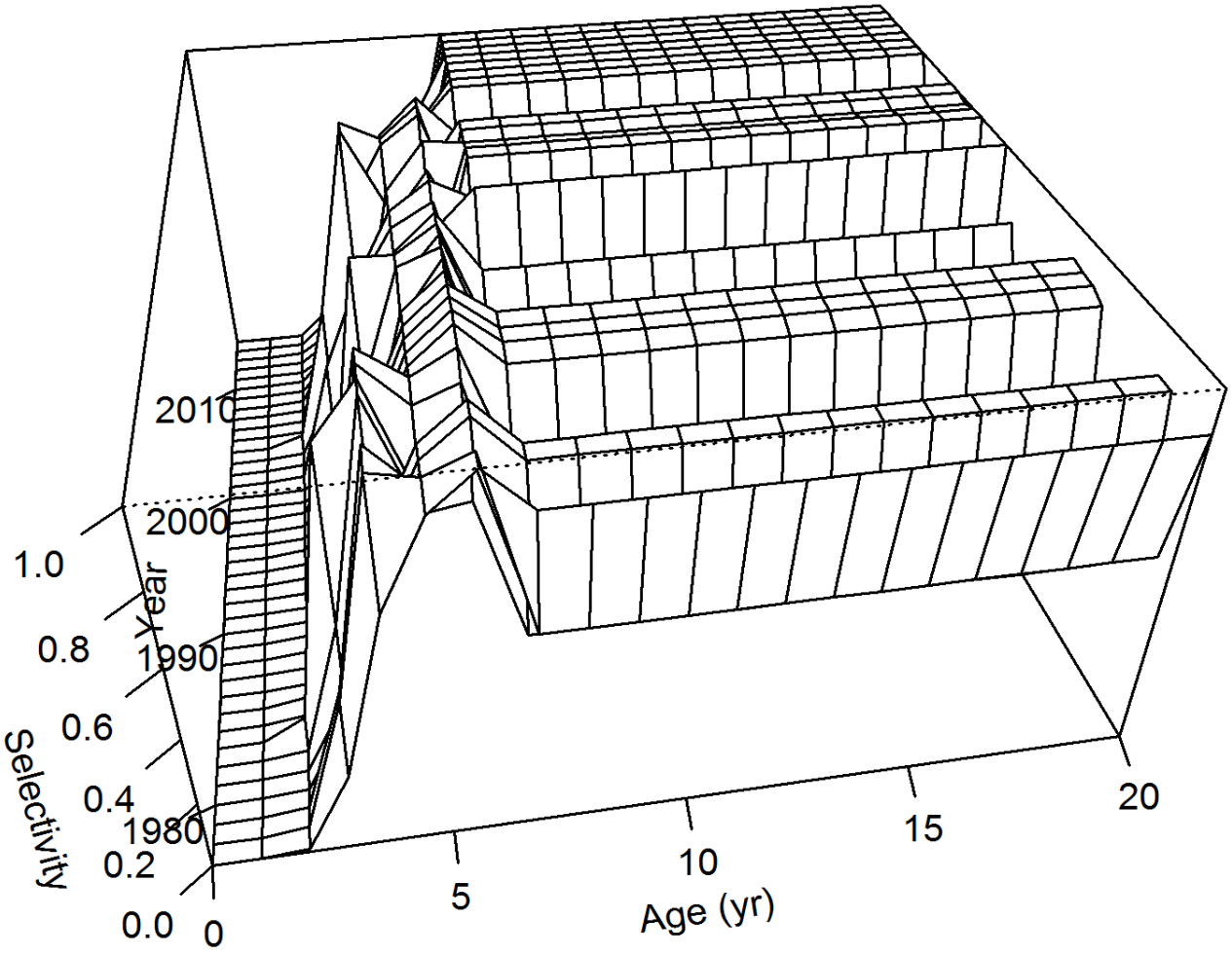
Fishery selectivity (Model 3)



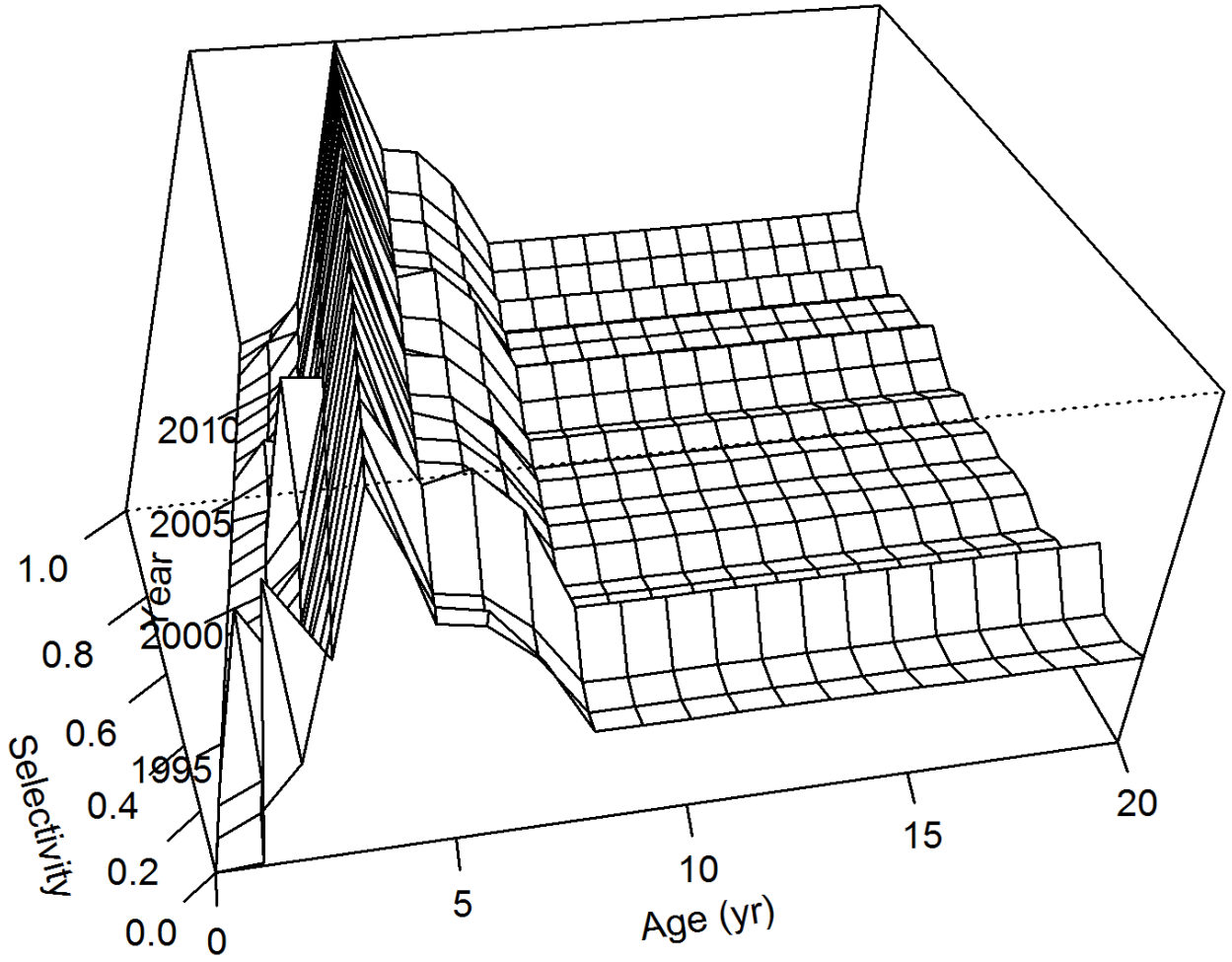
Fishery selectivity (Model 4)



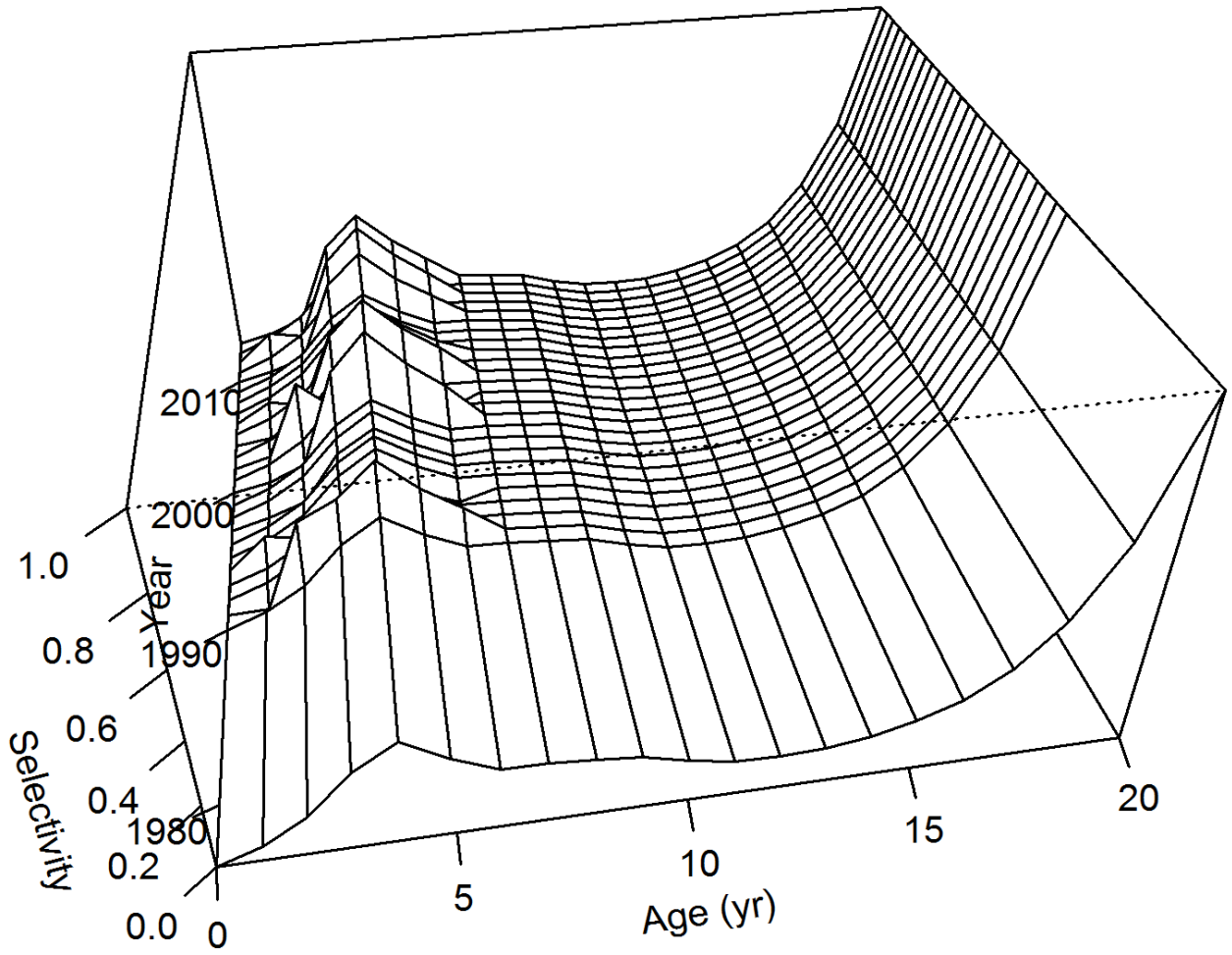
Fishery selectivity (Model 5)



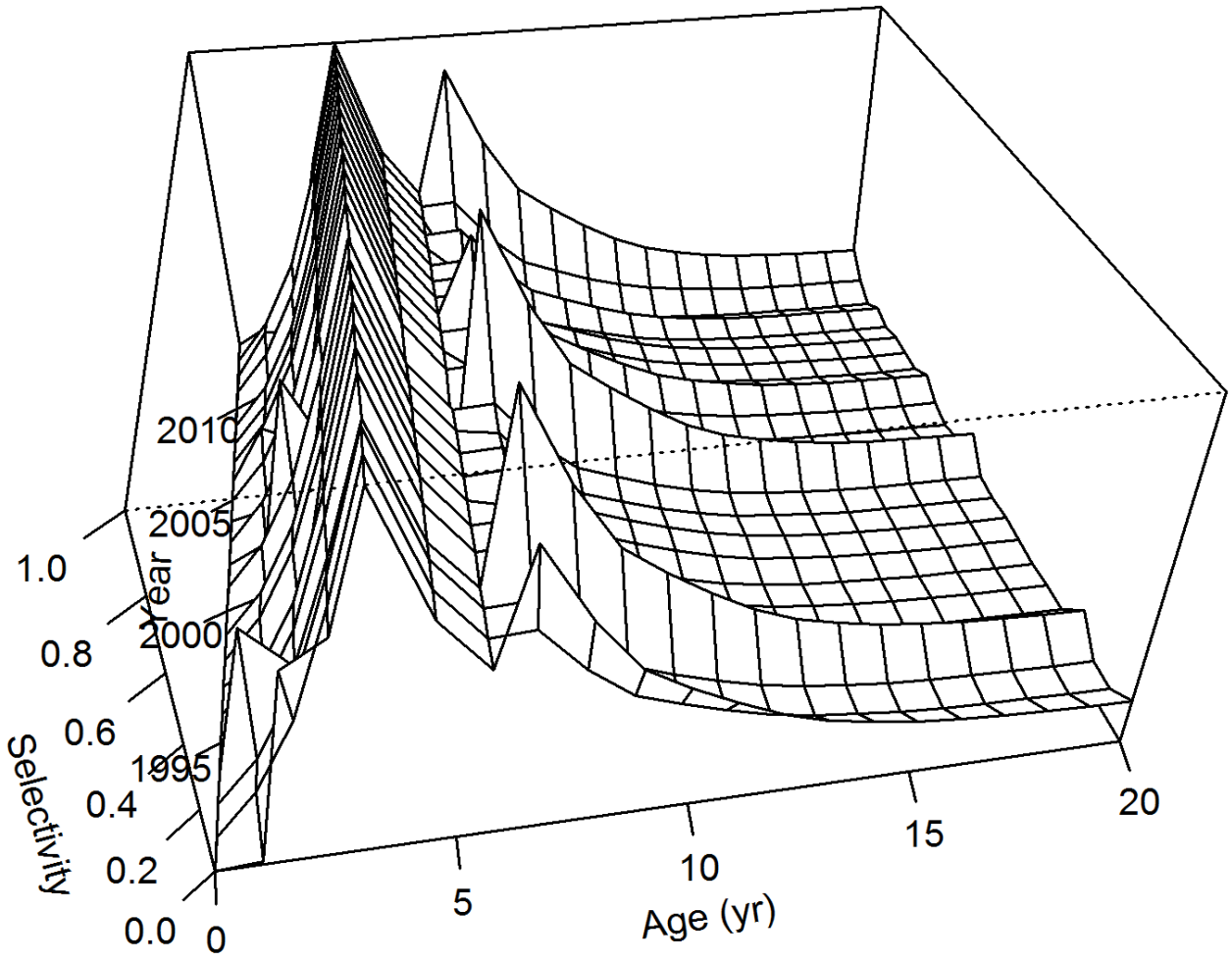
Survey selectivity (Model 2)



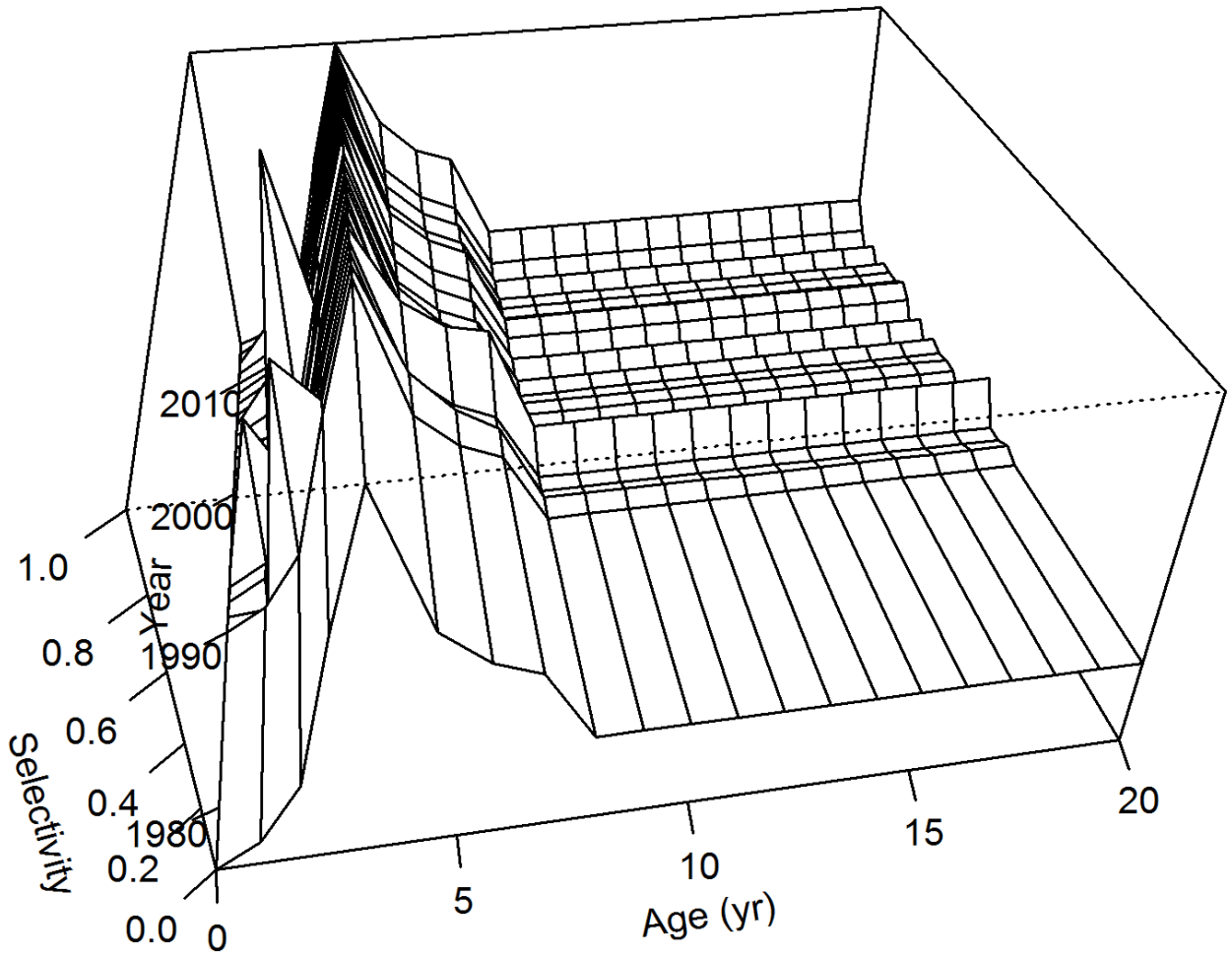
Survey selectivity (Model 3)



Survey selectivity (Model 4)

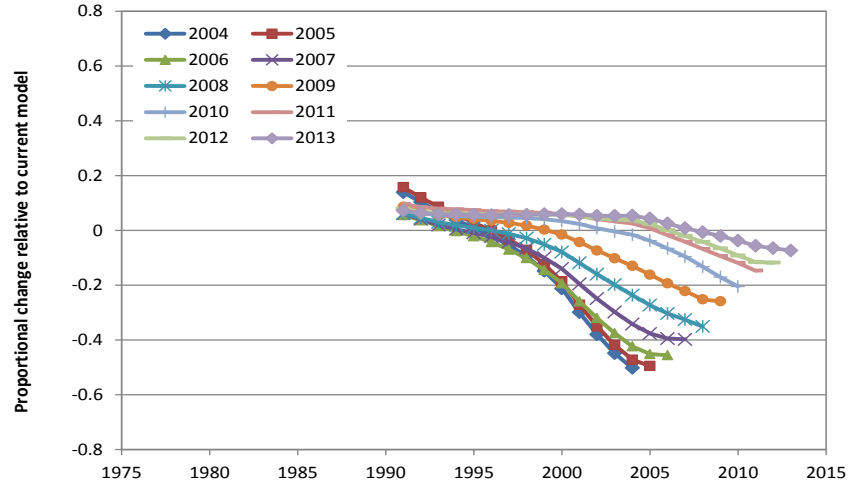


Survey selectivity (Model 5)

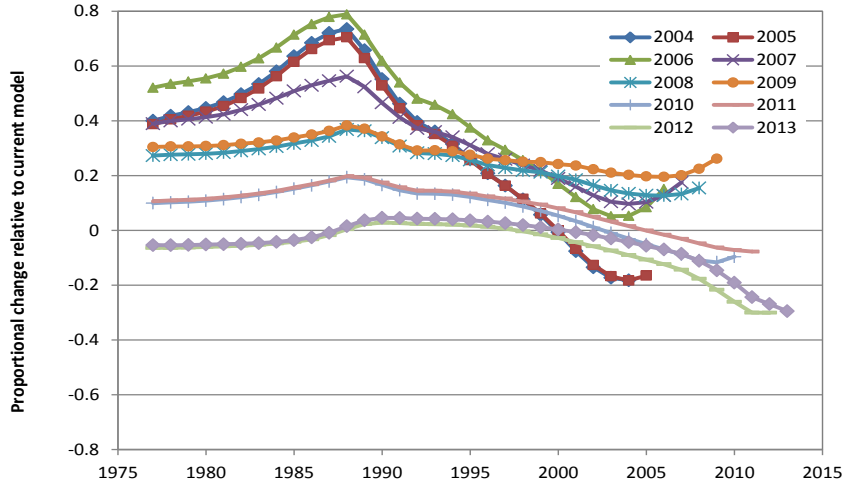


Retrospective comparison (relative scale)

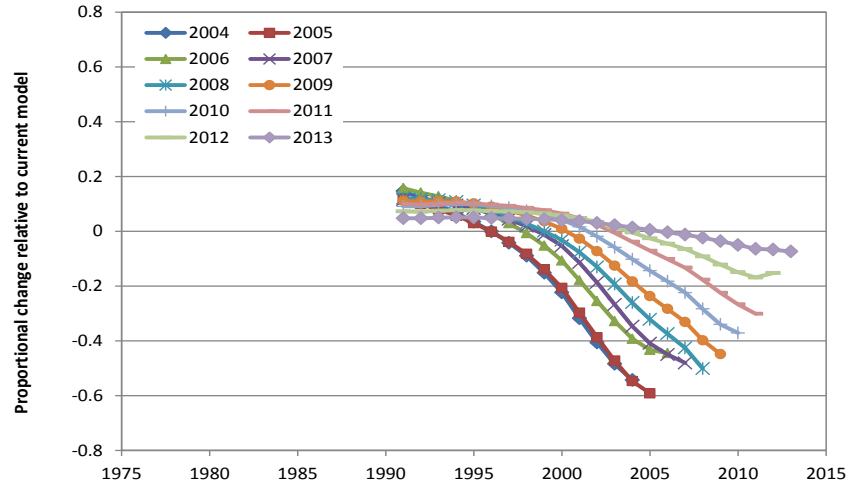
Model 2, rho = -0.300



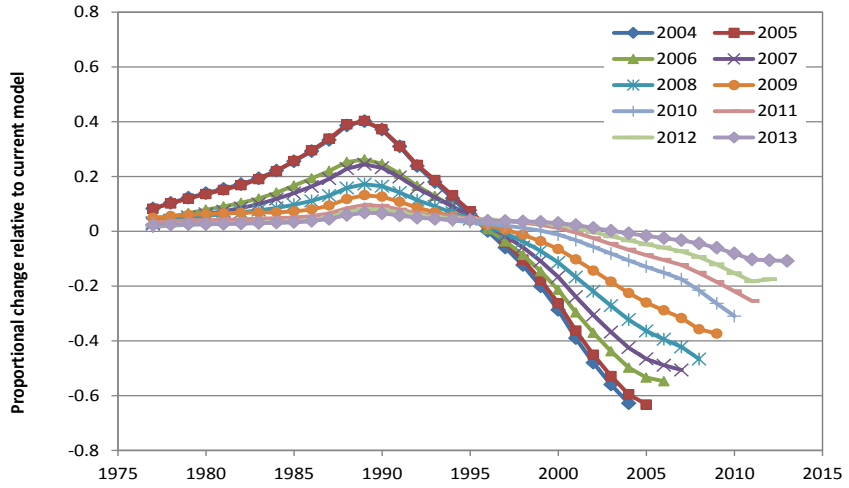
Model 3, rho = -0.037



Model 4, rho = -0.391

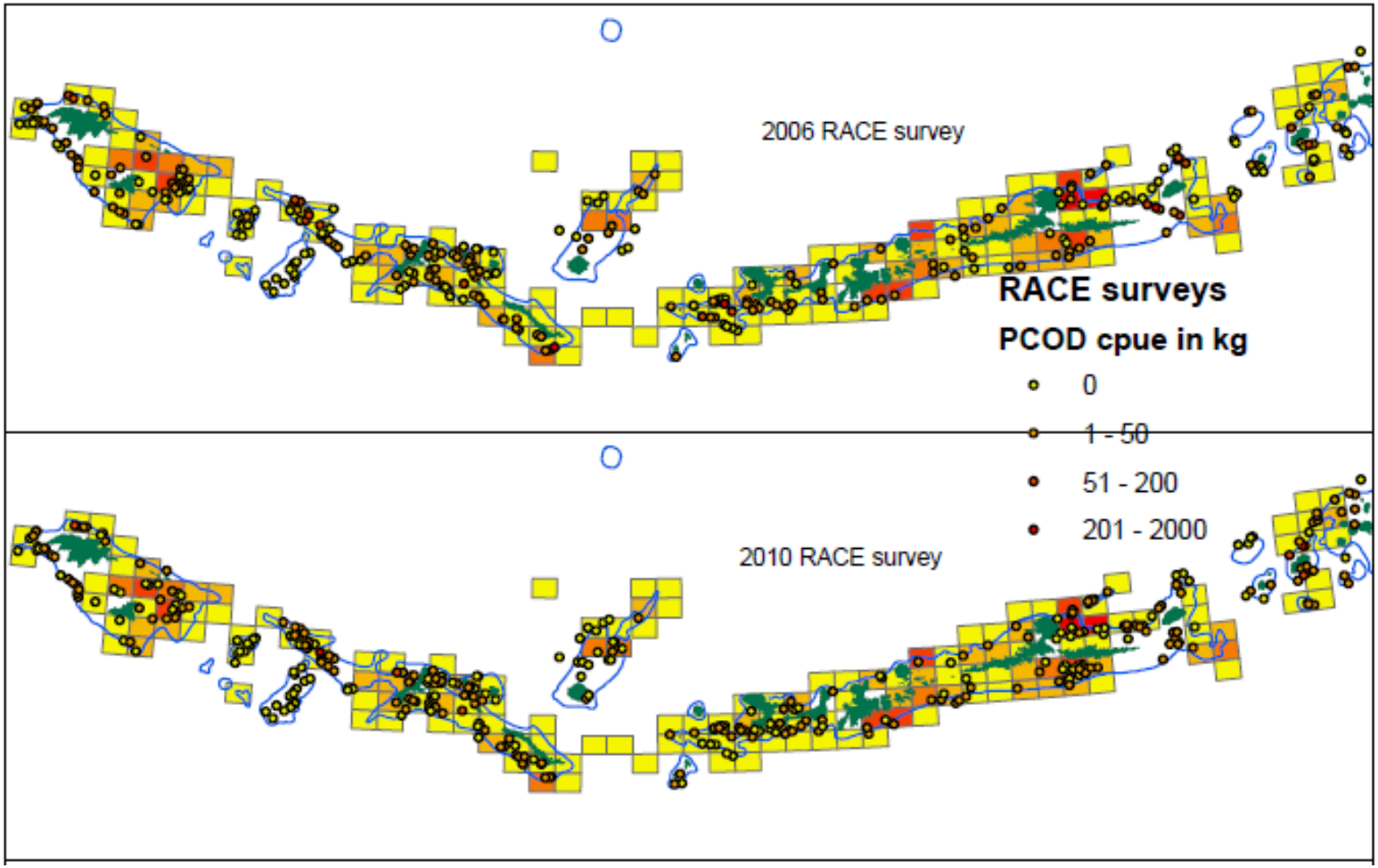


Model 5, rho = -0.400

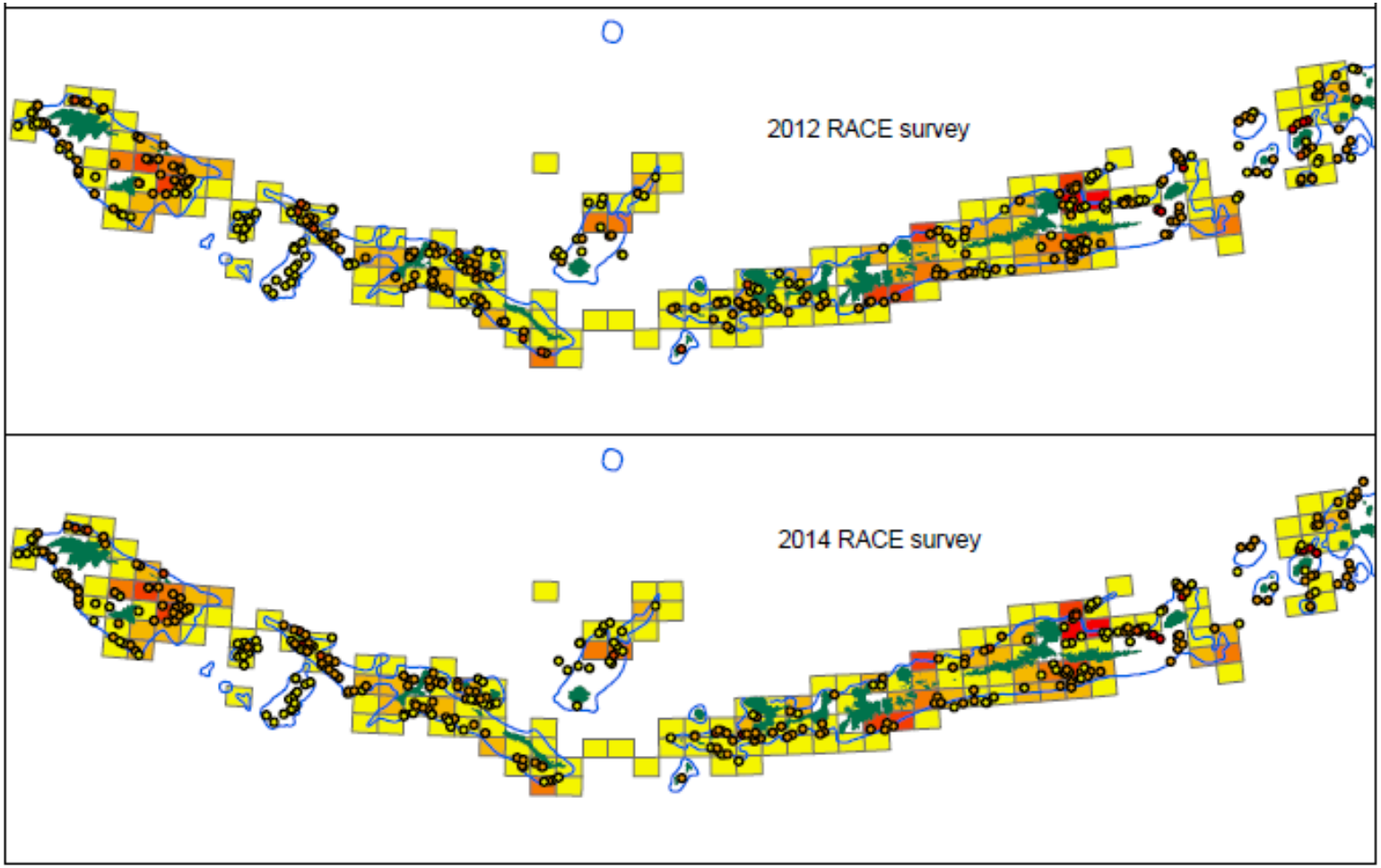


AI preliminary: other surveys

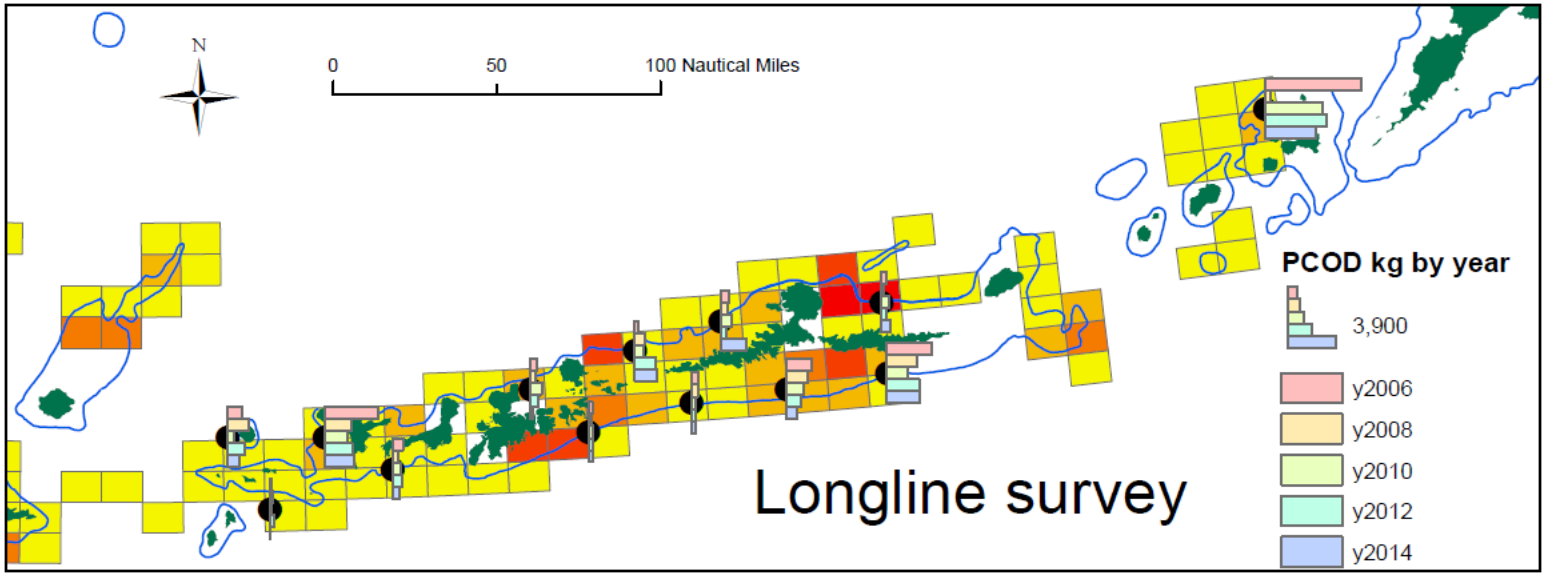
AFSC trawl survey vs. observed fishery (1 of 2)



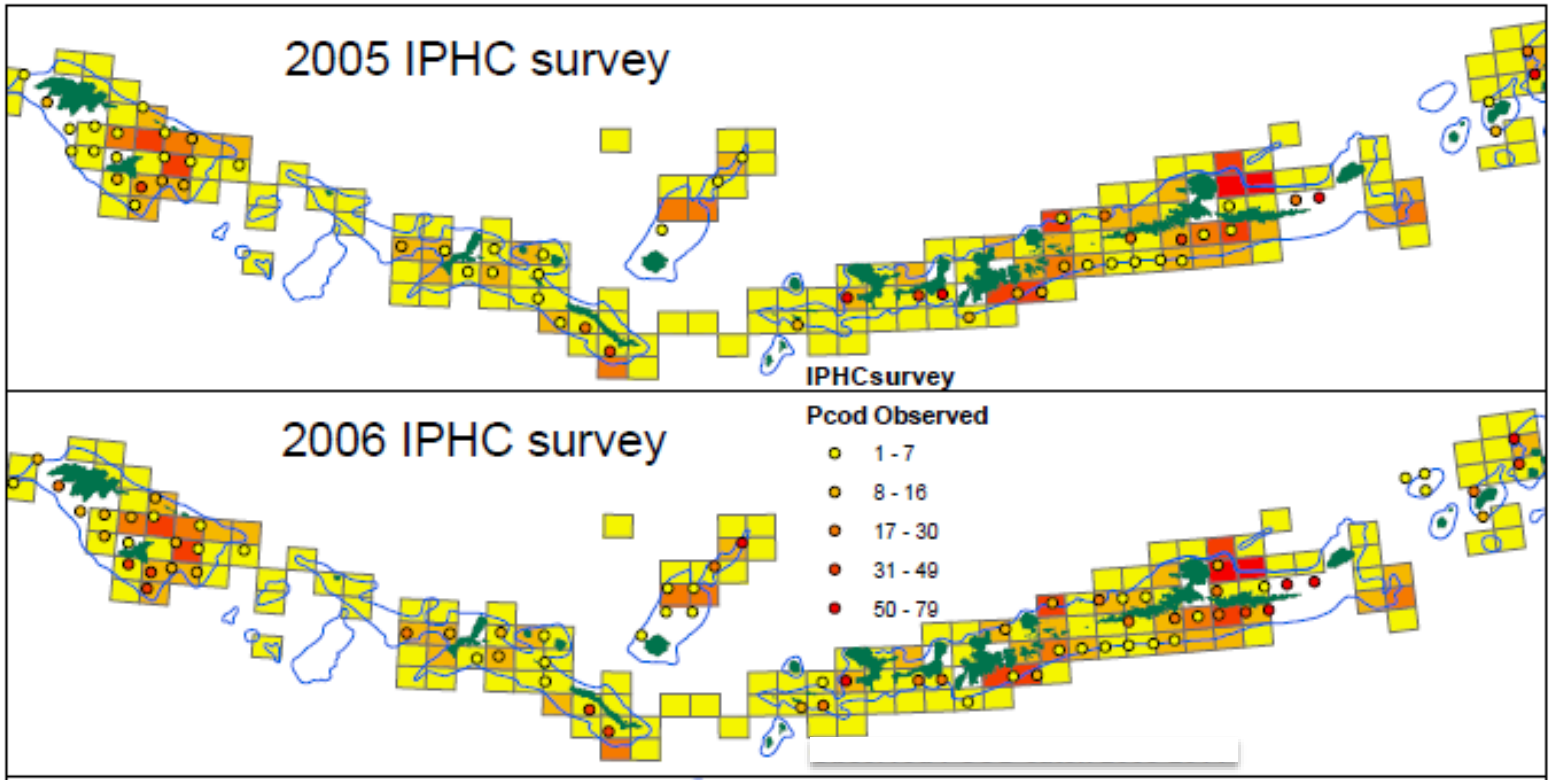
AFSC trawl survey vs. observed fishery (2 of 2)



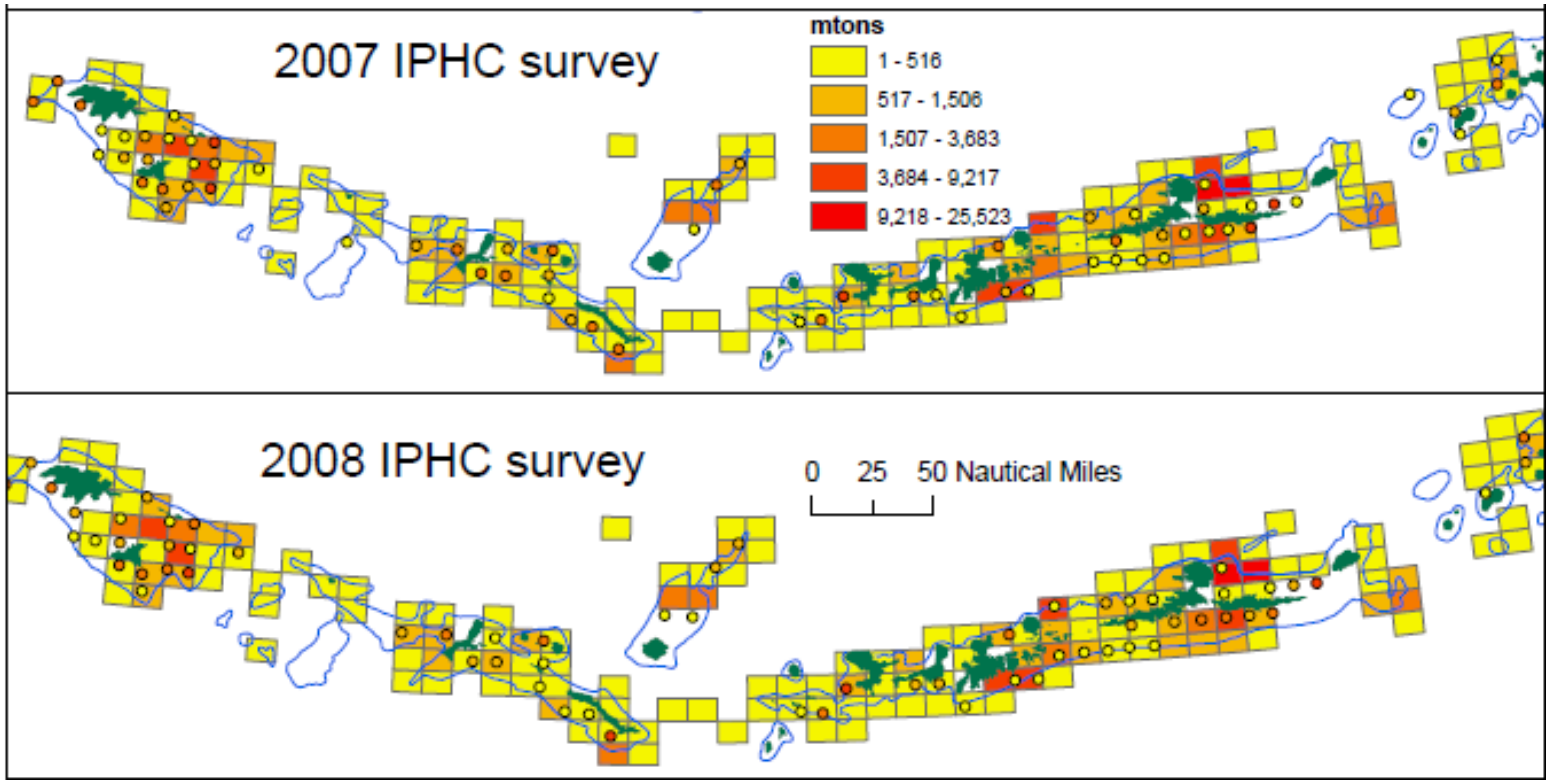
AFSC longline survey vs. observed fishery



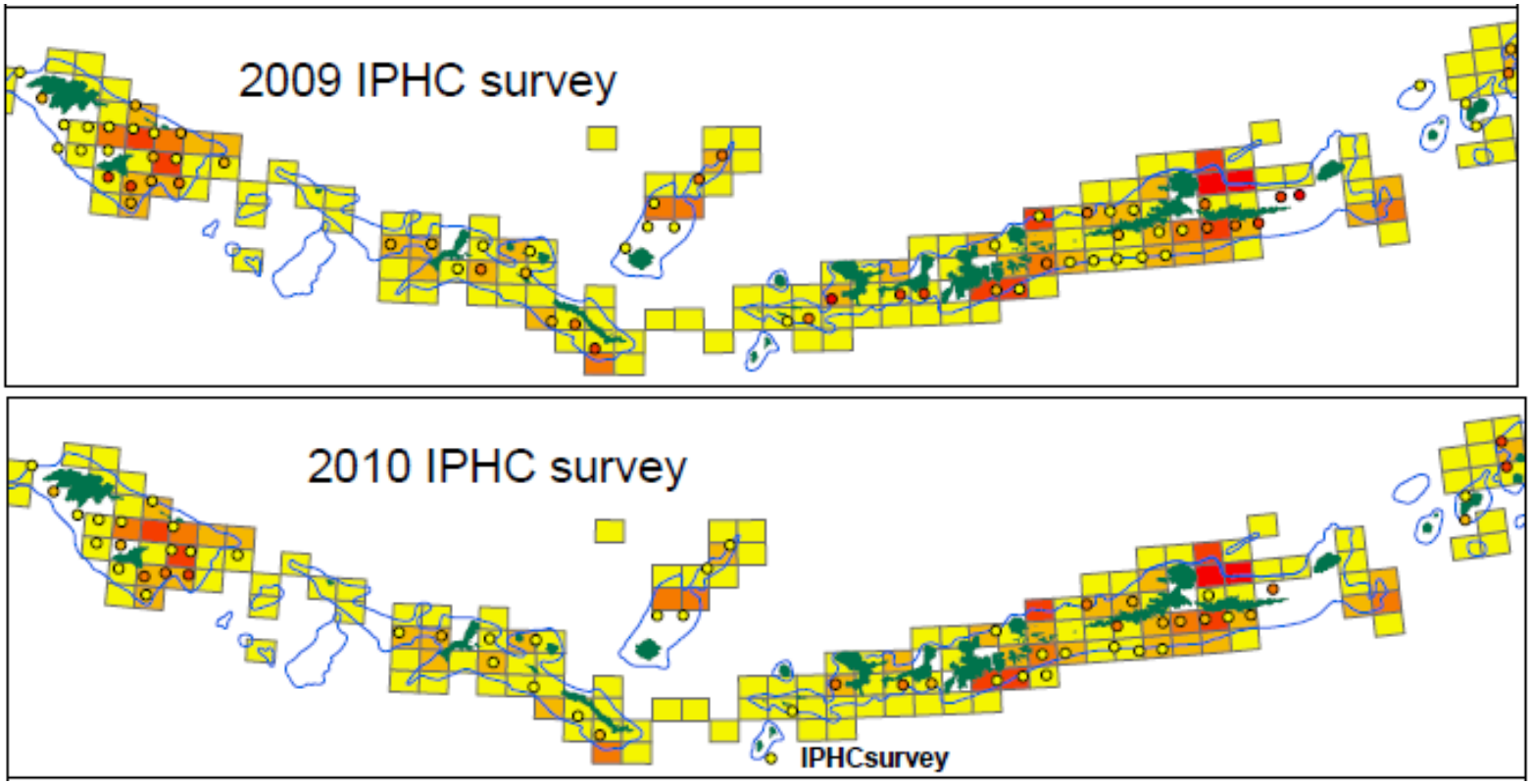
IPHC survey vs. observed fishery (1 of 5)



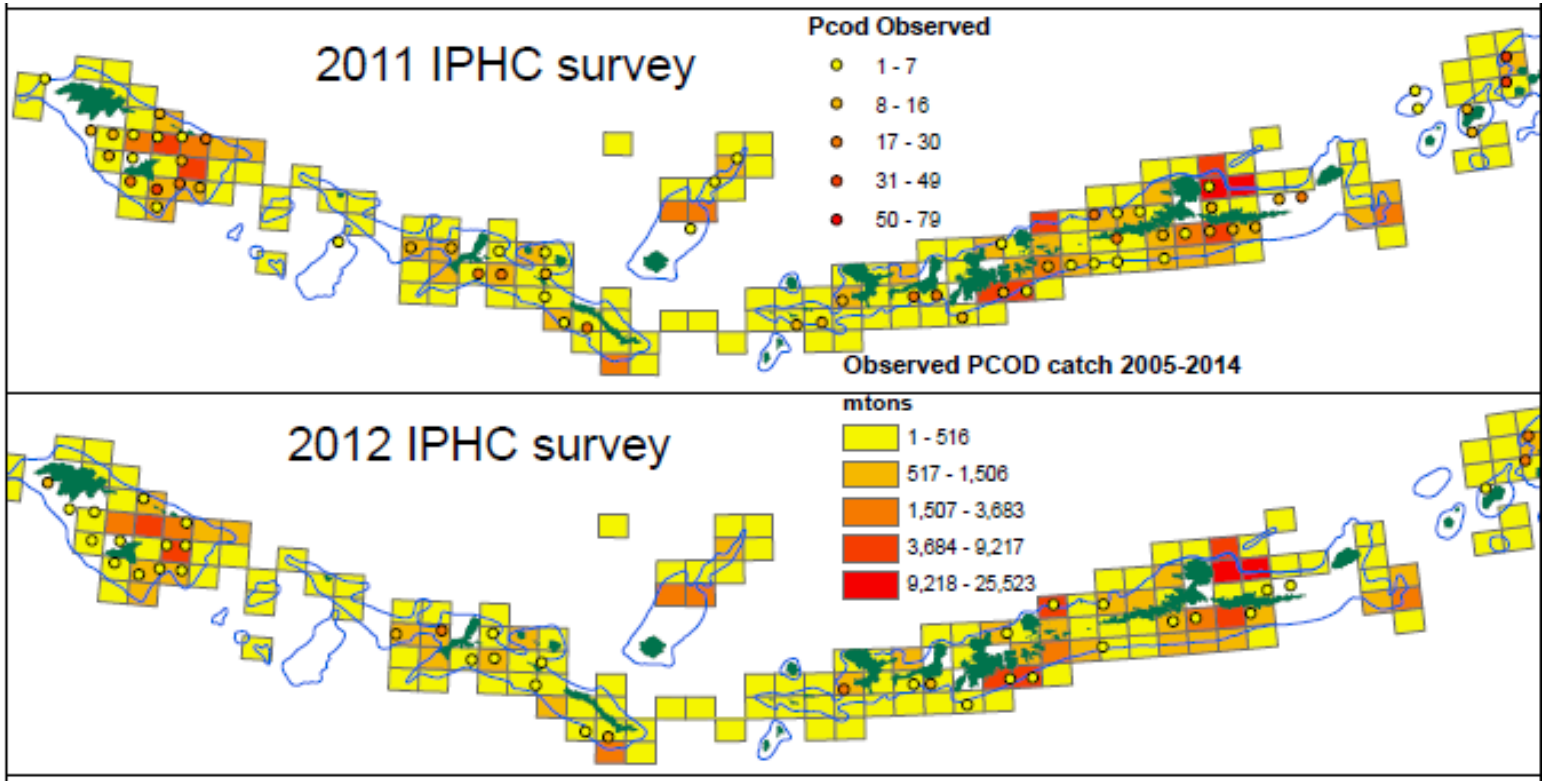
IPHC survey vs. observed fishery (2 of 5)



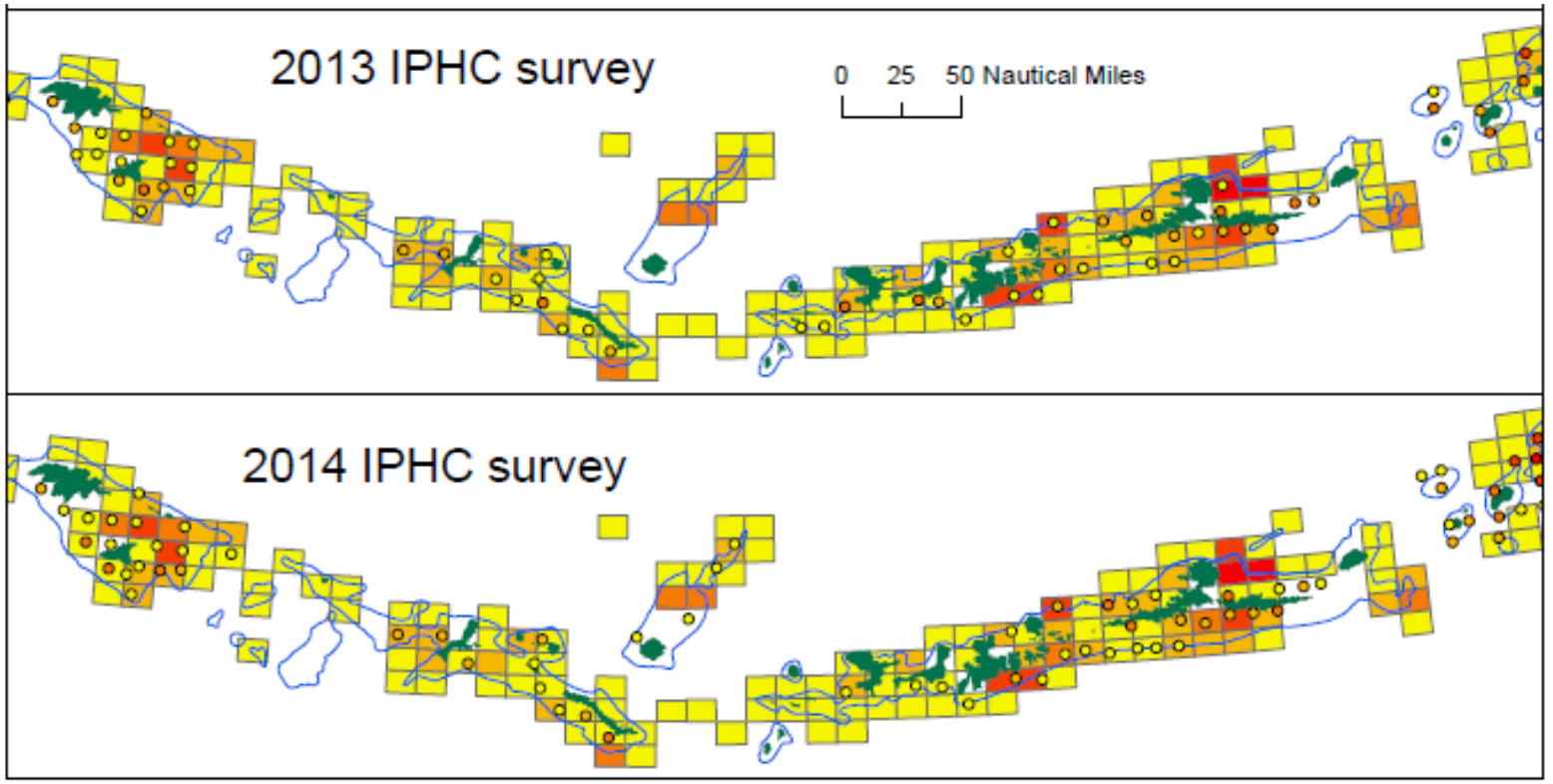
IPHC survey vs. observed fishery (3 of 5)



IPHC survey vs. observed fishery (4 of 5)



IPHC survey vs. observed fishery (5 of 5)



AI final assessment

List of models

- Two Tier 5 models:
  - Standard Tier 5 random effects model
    - Labeled Model 13.4
  - Modified random effects model, with IPHC survey RPN added as a second index
    - Labeled Model 15.6
- One age-structured model:
  - Same as Model 3 from preliminary, but with selectivity at older ages constrained, so as to prevent U-shape
    - Labeled Model 15.7

Fit to survey index: statistics

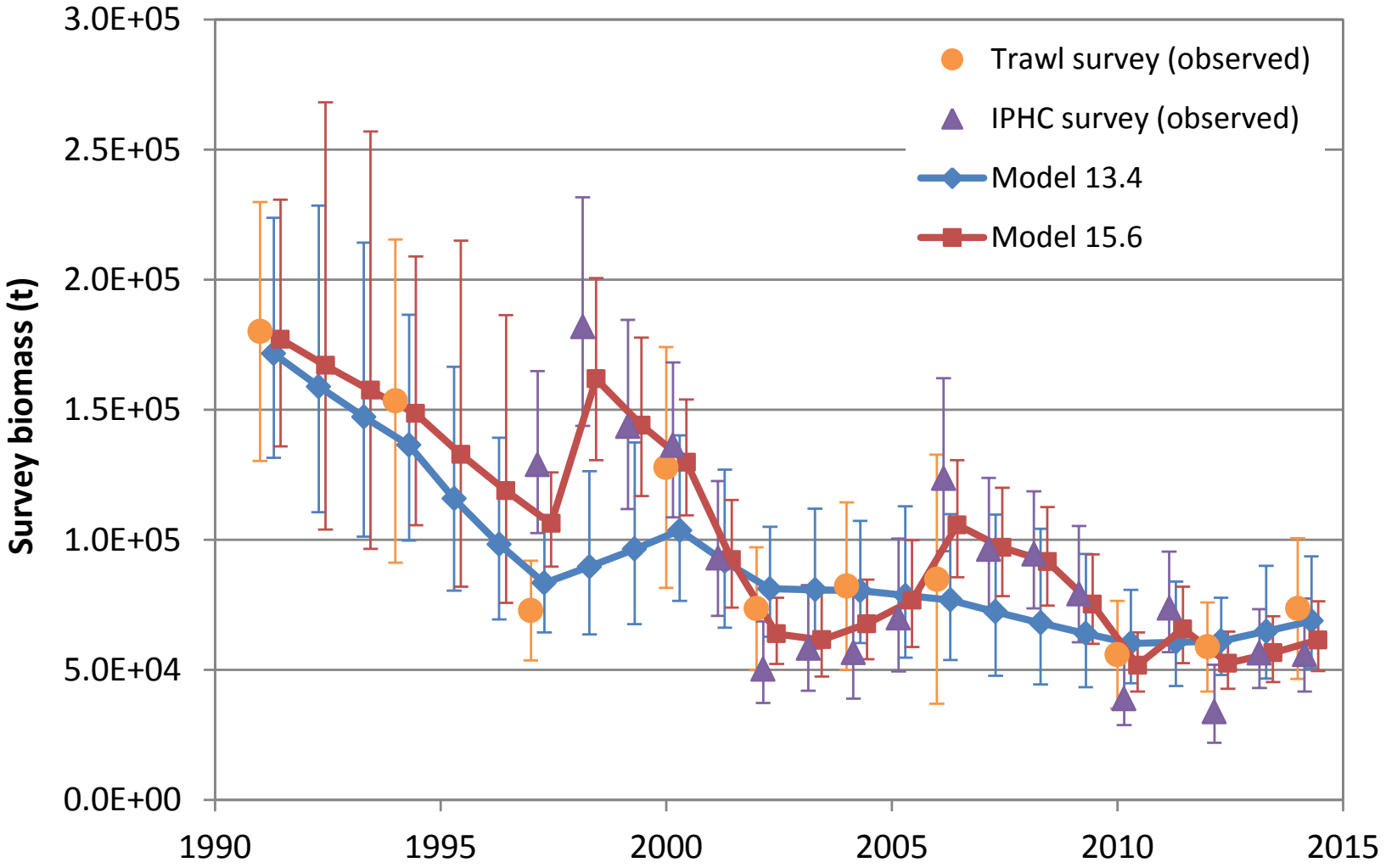
- Tier 5 (index = biomass)

Statistic	Model 13.4	Model 15.6
Correlation (observed:expected)	0.98	0.36
Root mean squared error	0.11	0.17
Mean normalized residual	0.06	0.06
Standard deviation of normalized residuals	0.63	1.15

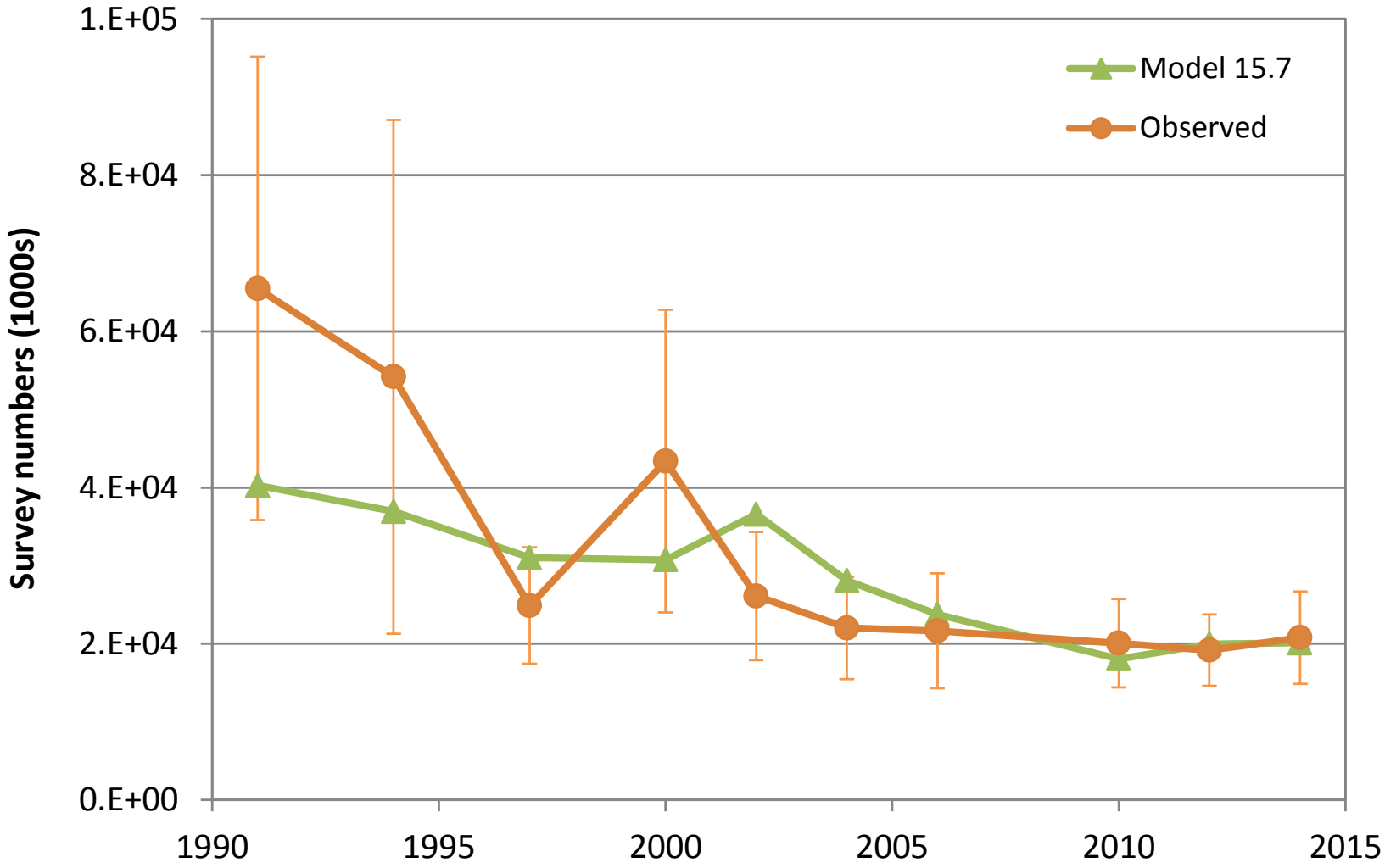
- Tier 3 (index = abundance; mean SE=0.18)

Statistic	Model 15.7
Correlation (observed:expected)	0.78
Root mean squared error	0.27
Mean normalized residual	-0.02
Standard deviation of normalized residuals	1.44

Fit to survey biomass (Tier 3)

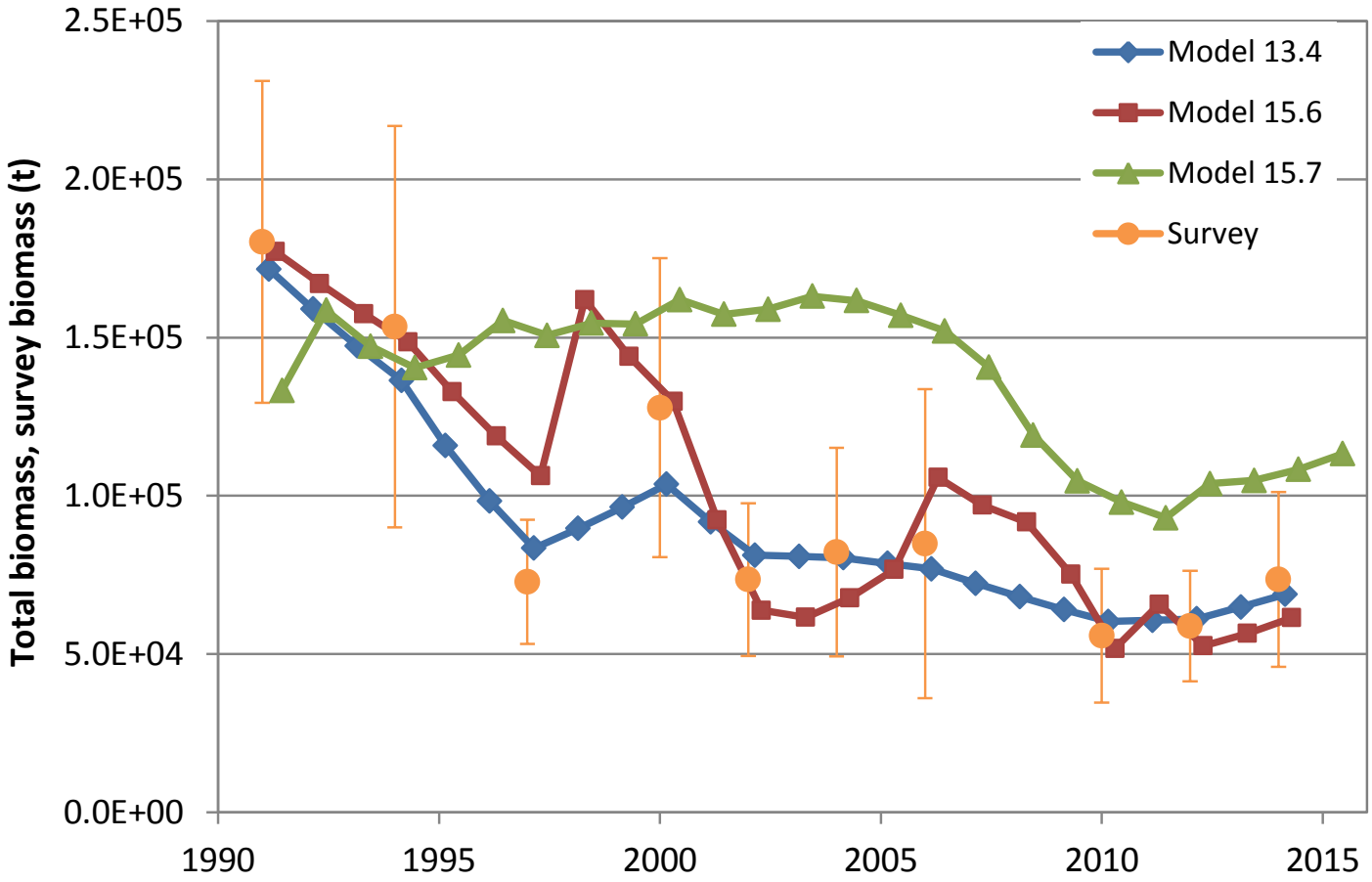


Fit to survey abundance (Tier 3)



Age 0+ biomass time series (with survey)

- Model 15.7 biomass = 159% of survey (on average); Q=0.86



Fit to composition data: statistics

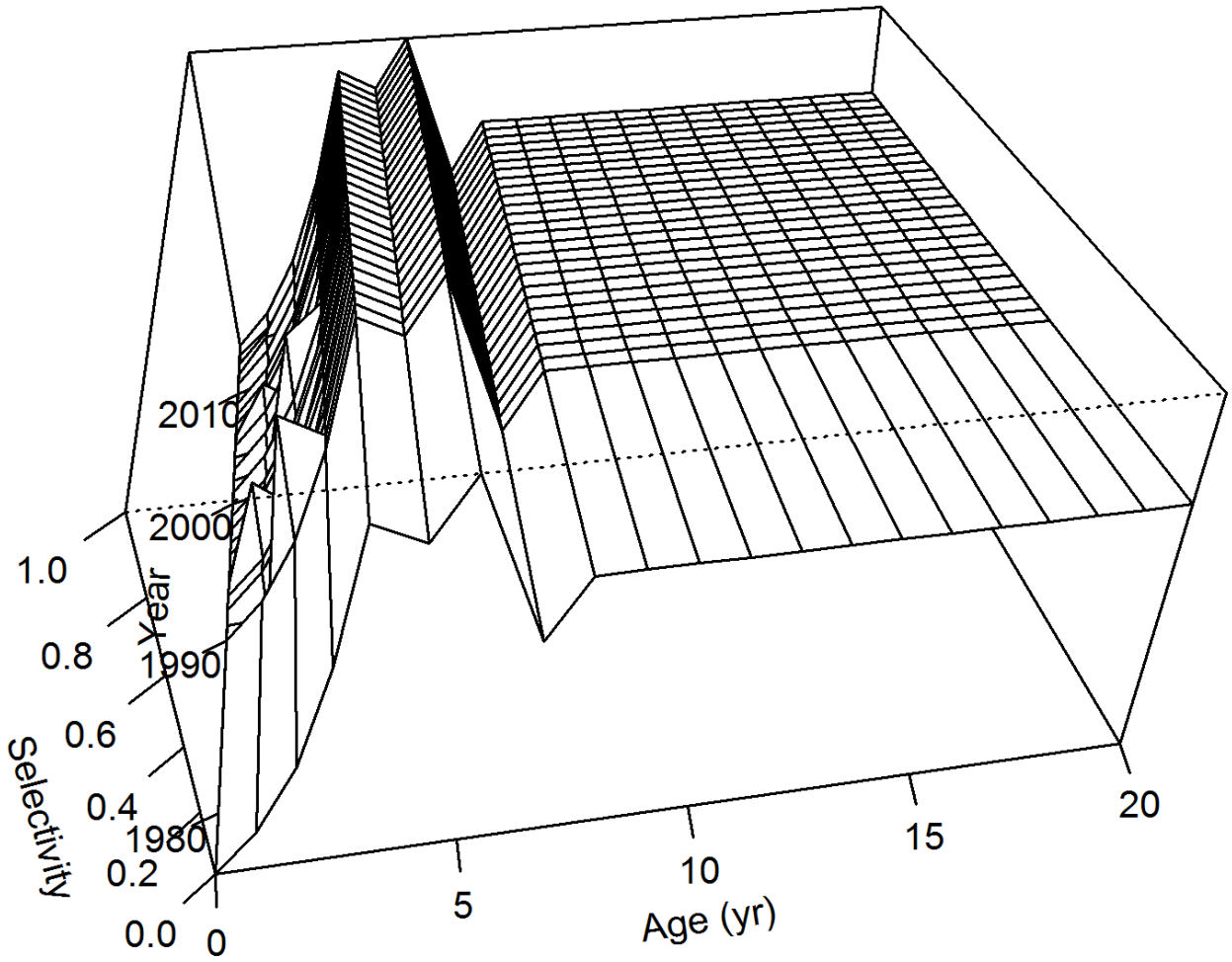
- Size composition data:

Fleet	Nrec	A(Ninp)	A(Neff/Ninp)	A(Neff)/A(Ninp)	H(Neff)/A(Ninp)
Fishery	32	300	15.72	12.02	4.99
Survey	10	300	3.29	3.01	2.00

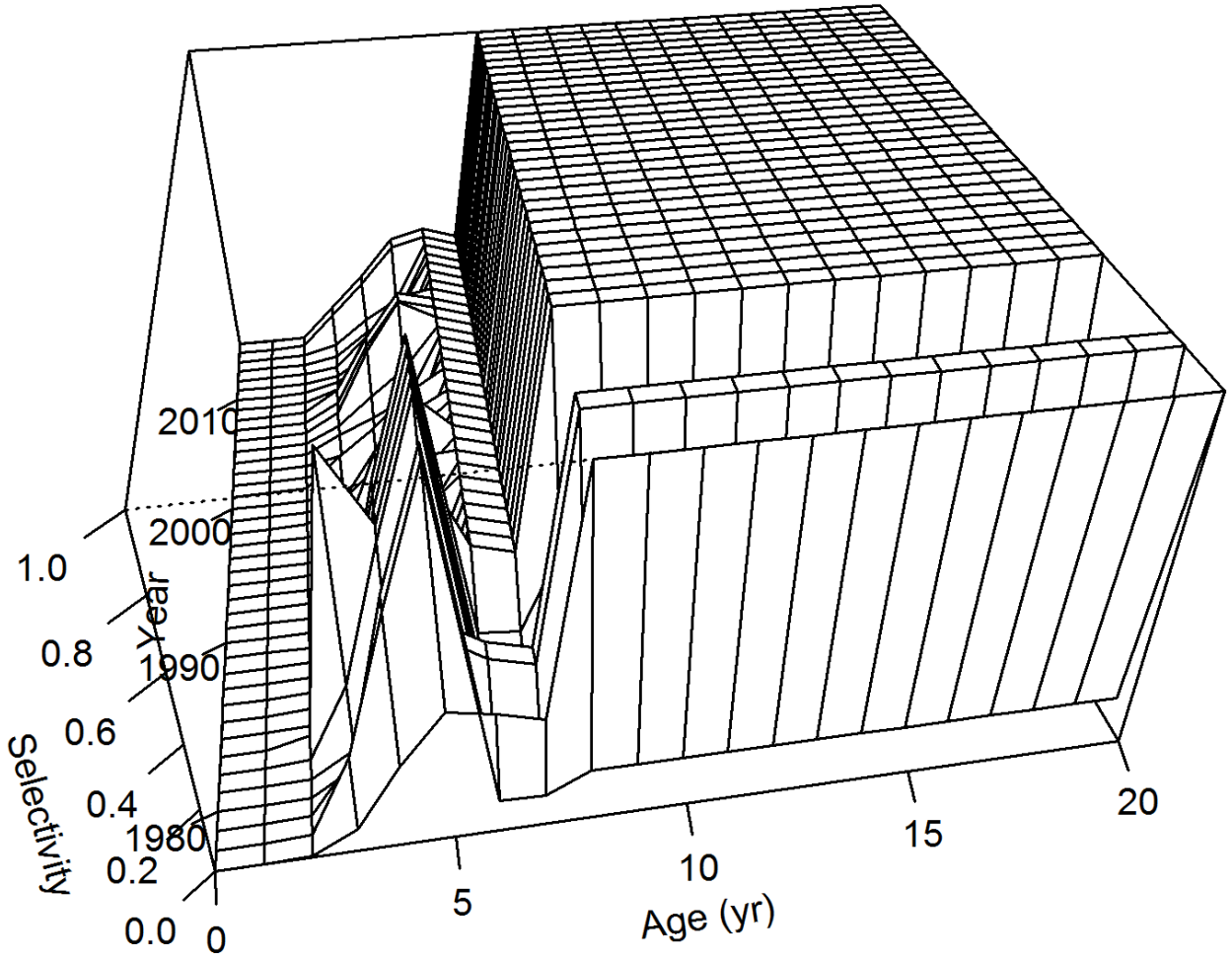
- Age composition data:

Year	Input N	Neff	Ratio
2002	168	166	0.99
2006	391	447	1.14
2010	345	51	0.15
2012	307	284	0.93
2014	289	106	0.37
Mean	300	211	0.71
Harm.	276	123	0.40

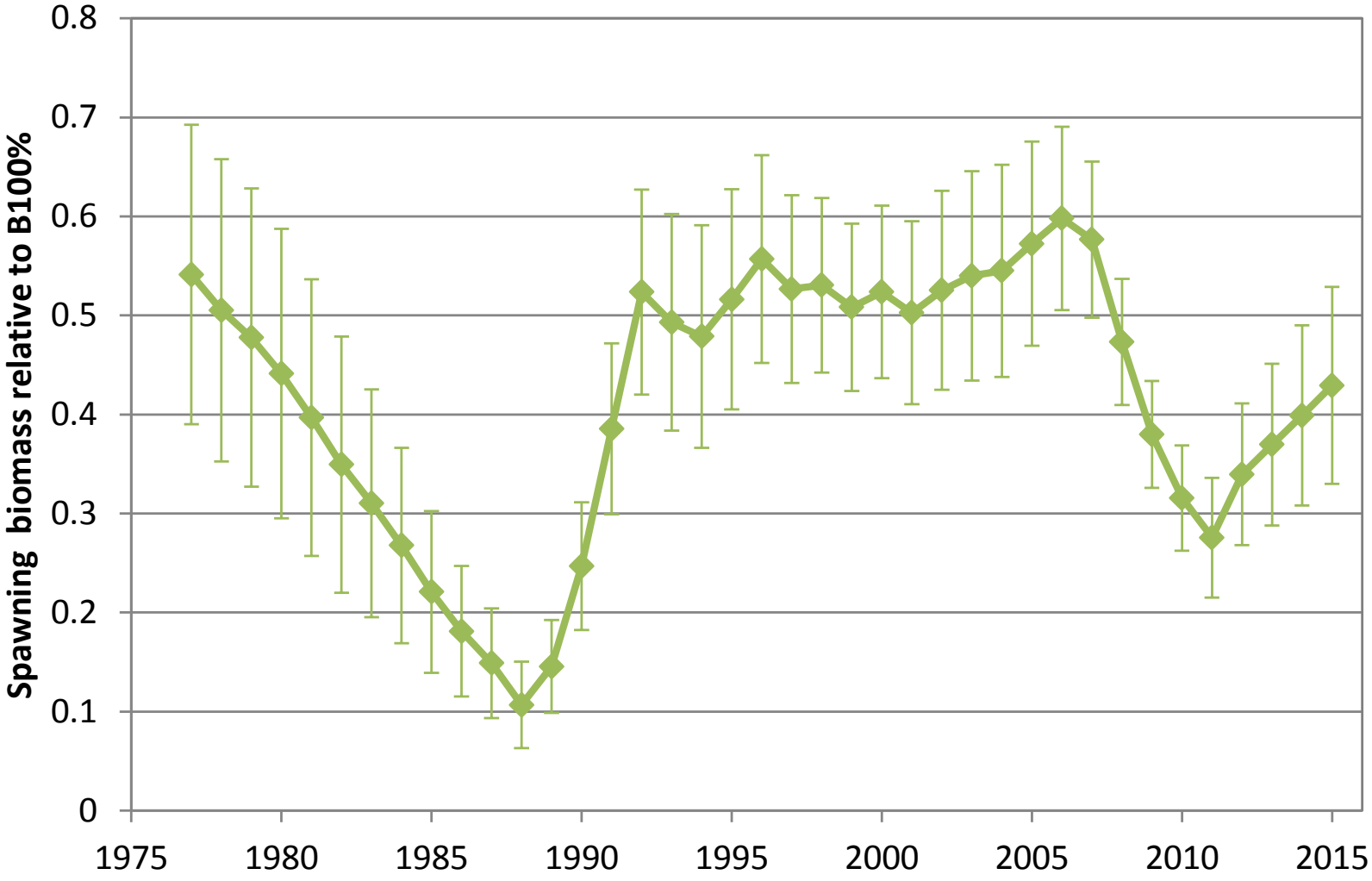
Survey selectivity



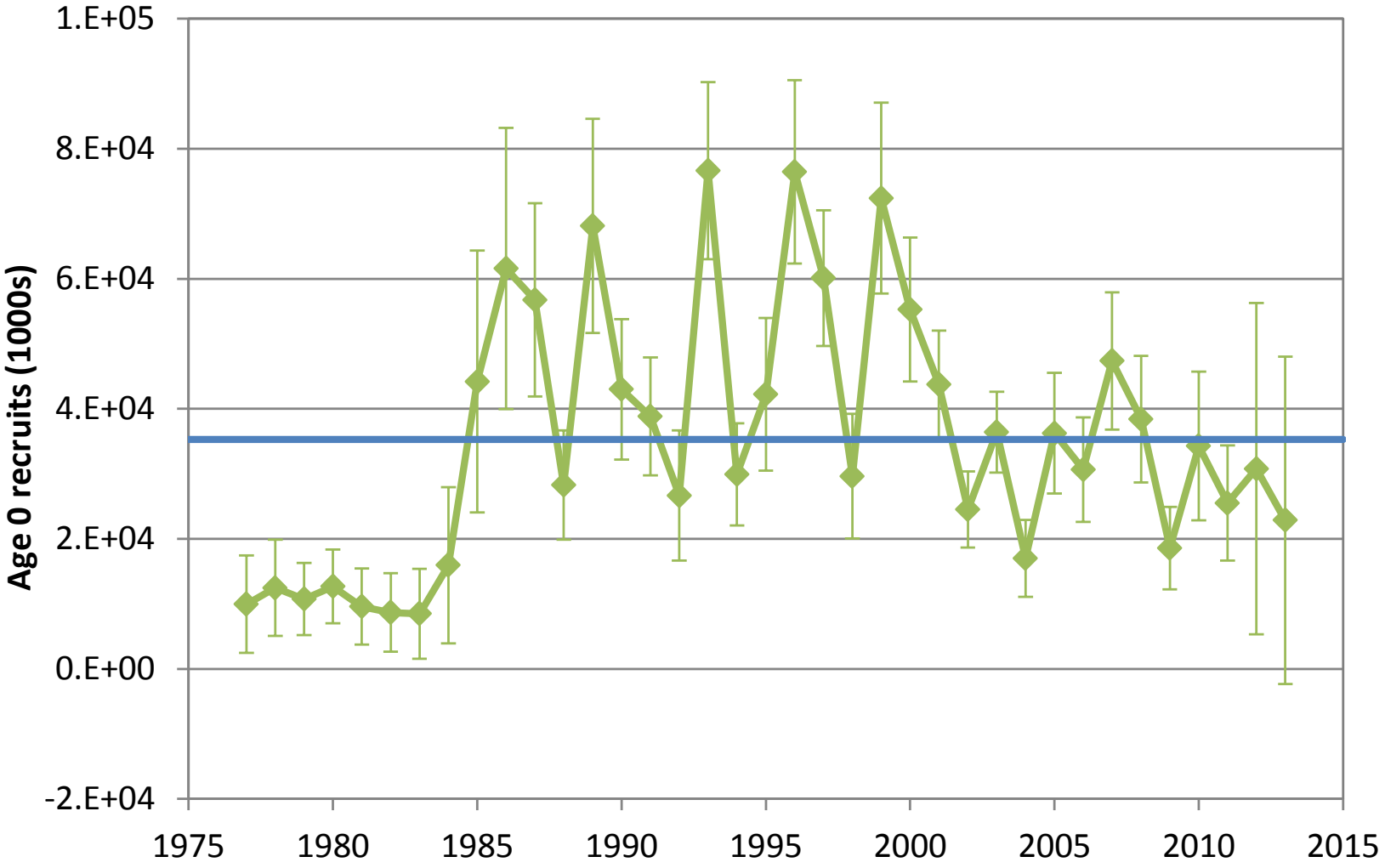
Fishery selectivity



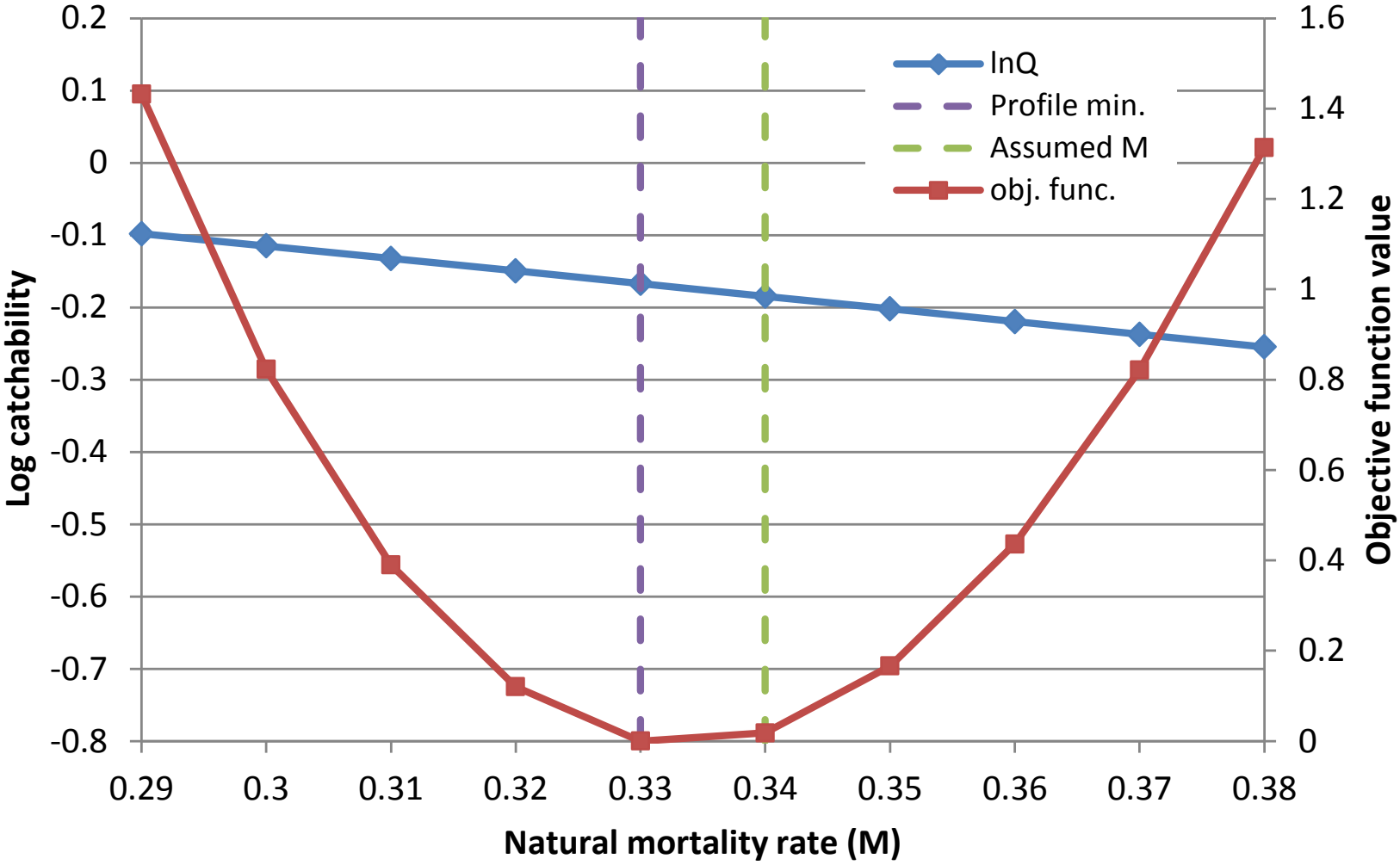
Relative spawning biomass (Model 15.7)



Age 0 recruitment (Model 15.7)



Likelihood profile w.r.t. M (Model 15.7)



Spawning biomass retrospective (Model 15.7)